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ORIGINAL ARTICLES.

I.—On the value of Mineral Condition in determining the Relative Age of Stone Implements.

By S. Hazzledine Warren, F.G.S.

The Classification of the Palæolithic Period.

THE common English classification of the Palæolithic Period into the epochs of the River-Drift Men and the Cave Men hardly conduces to clearness of thought. The implements of the River-Drift men are often found in the caves, and those of the Cave Men are very common in the river drifts. Although the caves and rock shelters bring us down to a later period than is usually represented in the river drifts (there appear to be exceptions to this [1]), yet the general succession in the two classes of deposits is the same, and they cannot be separated.

Without accepting all the more recently proposed earlier epochs,[2] I should certainly extend the classification one stage further backward in time than was originally done by M. de Mortillet.[3] That is to say, I would separate the derived implements from the contemporary Chelléo-Acheuléen implements of what are commonly called the 'high-level' river drifts. So far, I think, one may be fairly safe. For so far the relative ages of the implements are not inferred from their types, but the relative ages of the types, or rather of the series of types, are inferred from their mineral condition and the stratigraphical succession in which they are found. The peculiar types especially characteristic of one epoch are not confined to that epoch, but occur also in newer or in older epochs, or in both, as the case may be. But this fact does not prove the contemporaneity of our supposed epochs.

In all these problems one has to encounter a difficult combination of differences and resemblances. The implements of any one place

[1] See, for instance, Philippe Salmon, "L'Age de la Pierre à l'Exposition Universelle de 1889," Paris. Several later Palæolithic implements are figured on p. 29, etc., collected by M. G. d'Ault du Mesnil from the "Quaternaire moyen, assise supérieure" at Abbeville. Note also remarks towards the end of the present paper on Shrub Hill, Feltwell, etc.

[2] Some account of these may be found in various papers by M. A. Rutot in the Bull. Soc. belge Géol. Brux., 1900 and 1901, vols. xiv and xv.

[3] G. de Mortillet, "Classification des Diverses Périodes de l'Age de la Pierre": Congr. Inter. d'Anthrop. et d'Archéol. Préhist. Bruxelles, 1872, p. 432. "Le Préhistorique Antiquité de l'Homme," 1883, *passim*.

and time can be shown to have resemblances, more or less, with those of other places and other times. It is clear, however, that certain series of implements, found in certain beds, and possessing certain characters, are older or newer than other series of implements possessing different characters. But the fact that even the most highly specialized types are seldom absolutely confined to one epoch, shows that great caution must be exercised in drawing conclusions in the inverse order.

For convenience of reference I give the following modification of M. de Mortillet's scheme of classification, which, it seems to me, best expresses the relationships of the various epochs, and which I shall use in the course of this paper.

TABLE OF THE DIVISIONS OF THE PREHISTORIC AGE.

Periods.	Epochs with Type Stations or Examples.	Sequence Dates.
Recent (Holocene).	*Prehistoric Age of Metal.*	
	Prehistoric Iron Age. T.S.: La Tène (Palafitte), Lake Neuchatel	N. 90
	Presumed Transition Phase. T.S.: Hallstadt (cemetery), Austria	N. 80
	Later Bronze Age. Ex.: "La grande Cité" (Palafitte), Bay of Morges, Lake Geneva ...	N. 70
	Early Bronze Age, or Transition Epoch. Ex.: Palafitte of Roseaux, Bay of Morges, Lake Geneva	N. 60
	Neolithic Age.	
	Phase in which metal (copper and bronze) was known, but extremely scarce and little used. T.S.: Palafitte of Robenhausen	N. 50
	Presumed Earlier Phase, metal quite unknown. Ex.: the station of Campigny (Seine-Inférieure); also Cissbury (Sussex) and the Kjökkenmödding of Denmark (?)	N. 30
Pleistocene.	*Later Palæolithic Age.*	
	Magdalénien Epoch. T.S.: rock shelter of La Madelaine (Dordogne)	P. 90
	Solutréen Epoch. T.S.: "Le Clos du Charnier," at Solutré (Saône-et-Loire) ...	P. 80
	Middle Palæolithic Age.	
	Moustérien Epoch. T.S.: cave of Moustier (Dordogne)	P. 70
	Acheuléen Epoch. T.S.: the contemporary implements of the middle beds of the drift of Saint-Acheul (Somme)	P. 60
	Earlier Palæolithic Age.	
	?[Chelléen Epoch. T.S.: the earlier drift of Chelles (Seine-et-Marne).]	[P. 50]
	The earliest known phase of the Palæolithic Period. T.S.: the drifted Palæolithic (not 'Eolithic') implements of the Plateau Drift of Kent. (Appears to cover a long period and may be capable of subdivision.) ...	P. 30–40

In this table I have ventured to give 'sequence dates' to the epochs, after the system that has been used by Professor Flinders Petrie.[1] I have not attempted, however, to give a similar value to each unit of the scale, other than that suggested on taking a general view of the stratigraphical successions in various districts.

In doing practical work one finds at every turn the advantage of these 'sequence dates' over a system of epochs alone. Where the epoch of implements is but ill-defined, which is very often the case, these 'sequence dates' are of especial value. Instead of speaking of implements as Acheuléen, which may be far from contemporary with those properly belonging to that epoch, one can assign them as s.d. P. 50–70, or whatever it may be—just so much as can safely be made out.

I have queried the Chelléen Epoch, as a matter of doubt. What one might call the typical river-drift implements were originally called Acheuléen. Subsequently M. de Mortillet[2] thought that they showed evidence, at Saint-Acheul and elsewhere, of a transition to the Moustérien, and proposed that they should be called Chelléen, the Acheuléen being considered intermediate. Other workers, as M. G. d'Ault du Mesnil,[3] have considered the Chelléen and Acheuléen to be worthy of separation into two distinct periods. M. A. Rutot,[4] again, looks upon the Chelléen as a phase of transition between the earlier 'Mesvinien' and the Acheuléen. The point has not been satisfactorily cleared up, but there is evidently a gap between the Earlier Palæolithic (P. 30–40) and the Acheuléen (P. 60), and, in addition, there seems in some localities to be a series that is of intermediate age. But whether these apparently intermediate forms at P. 40–60 are really to be correlated with the Chelléen of Chelles I am not prepared to say. In using 'sequence dates' one need not debate the point. Until further exact work has cleared the matter up, it is more prudent to give them a sufficiently wide range to be safe in any event. In the table I have suggested P. 50 for the Chelléen, should that be found to be satisfactory, but for the present it is better to class both these and all other similar series at P. 40–60, and narrow the range down, at one end or the other, as evidence accumulates.

Local details, wherever these are obtainable, may be written thus: N. 40–60, l. 30–45, that is to say, there are a series of relics from some locality coming correlatively (but not necessarily contemporaneously) into the general scale at N. 40–60, of which the particular object or type classed comes into the local scale at 30–45. Or these formulæ may be written in the form of fractions or decimals, as may be most convenient for the work in hand.

There are many more points on which one might say much, but I think that what I have said is sufficient for my present purpose, so I will pass on to consider the question of the value of the mineral condition of stone implements as a test of their relative age.

[1] Journ. Anthrop. Inst., 1899, vol. xxix, pp. 295–301.
[2] "Le Préhist. Antiq.," etc., 1883, p. 133 et seq.
[3] Philippe Salmon: "L'Age de la Pierre," etc., 1889, p. 17.
[4] Bull. Soc. belge Géol. Brux., 1900, vol. xiv, p. 326.

The Mineral Condition of Stone Implements.

Every collector is familiar with the great variety in mineral condition presented by stone implements, according to the accidents of their preservation. Palæolithic implements are quite as often found unabraded, unaltered, or whitened in condition as they are abraded or with an ochreous patina. And, on the other hand, Neolithic implements are not only found unaltered or whitened, but occasionally also ochreous, especially where they were made of flint that previously had an ochreous patina. More than this: as an implement lay flat in a gravel bed, or whatever it might be, the upper surface is often in quite a different condition from the lower. Or, with an implement broken in early times, it is occasionally found that the two or more pieces, though fitting together accurately, are yet each in a different condition. It must be emphatically stated, then, that when implements are merely viewed in the trays of a cabinet, mineral condition is no test of age. It is equally notorious that rudeness of workmanship in individual specimens is no indication of antiquity. Very rude stone implements were made, not only during the Neolithic Period, but even, apparently, after the introduction of metal. From these causes the subject has fallen into discredit with many of our more cautious geologists. It has been too hastily assumed that the same is the case no matter what the circumstances may be under which they were found in the field.

With regard to rudeness of workmanship being no indication of antiquity, one might say more. The evolution of implements of certain types not only passes through successive phases of advancement, but also to this development there may succeed a degradation of form; probably, in most cases, through the introduction of some better material to supply the same needs. Professor Flinders Petrie[1] believes this to have been the case with the beautiful flint knives of Egypt. In the prehistoric graves he traces a certain succession (N. 40–55, l. 30–80), and finds that the curved knives with ripple flaking were developed at N. 40–55, l. 57, from a similar form made previously by irregular flaking. But these beautiful flat, ripple-flaked, knives only continued in use to N. 40–55, l. 65, after which time there was a recrudescence to the earlier style, and this continued in use into the early historic times.

One sees a similar phenomenon, on a larger scale, during the Palæolithic Period. The development of the flint-working industry may be traced[2] up through the Chelléo-Acheuléen and the Moustérien, until it reaches its highest excellence and skill in the Solutréen. But towards the end of that epoch the bone industry began to assume greater importance, until in the Magdalénien it attained an extraordinary development, while the flint industry fell comparatively into decay.

In September, 1900, I described in this Magazine a Palæolithic drift on High Down, in the Isle of Wight, and suggested that the

[1] Journ. Anthrop. Inst., 1899, vol. xxix, pl. xxxiii.
[2] G. de Mortillet: "Le Préhist. Antiq.," etc., 1883, pp. 355–367.

implements probably belonged to two distinct epochs. At about eighteen inches from the surface in this clay drift there was what I called a "layer of stones." On sorting out the flints (both worked and unworked) from this layer of stones, according to their mineral condition, I found that they fell into the following classes :—

A. Abraded and corroded ; with a deep brown patina.
B. Much corroded and abraded; whitened over an earlier ochreous staining. Not very abundant.
C. Somewhat abraded ; commonly mottled with white over a slight ochreous staining (red more often than brown or yellow) ; the whole patina very superficial.
D. Unabraded ; practically unaltered in condition.
E. Unabraded flint nodules and fragments ; more or less bleached white. Implements rare in this condition.

Leaving class C out of account for the moment, I will proceed to show that while A and B are derived from an earlier drift, D and E are contemporary, or nearly so, with the deposit in which they were embedded. One might hazard a guess that A and B were older than D and E, simply from the fact of their being abraded, corroded, and ochreous in condition, but a more careful examination shows the evidence to be far stronger than this alone would be.

Many of the flints in condition A and B are found to be broken across, the later fractures being in condition D or E. These specimens, showing fractures of two different ages, are clearly defined from those which show a different condition on their two surfaces through some accident of preservation. Firstly, the later fractures in the former case very rarely occupy exactly one surface of the flint. Sometimes the newer fractures are a mere chip on the edge, sometimes it is a corner of the flint that has been knocked off, or sometimes the flint has been broken up and only a very small surface in the earlier condition remains. Secondly, these later fractures show all round their edges a clear section of the earlier deep patina of the flint : this is the absolute distinction between them.

Under these conditions, whatever value the difference in age may have, it is demonstrable that the deeper patina is geologically older than the later fracture which crosses it, though this later fracture may also be of geological antiquity. Mr. Worthington G. Smith [1] has figured and described ochreous abraded implements showing later fractures on their edges, and strongly insisted on this proof of their greater antiquity.

It is, after all, only applying the well-known, and fully admitted, principle in stratigraphy, of discriminating between contemporary and *remanié* fossils, to the similar problems presented by flint implements. But, undoubtedly, caution and judgment must be exercised in applying the principle. Differences of condition, of the kind that have been pointed out, prove differences of age, but they do not immediately prove that every difference in age belongs to

[1] "Man the Primeval Savage," 1894, p. 216.

a distinct epoch or stage of human culture. Nor does the condition of the flints, by itself, show to which phase they should be referred.

In the "Grotte du Placard" (Charente)[1] there are eight relic beds, each separated by an accumulation of rock débris, and yet these can only be referred to four of the epochs. The lowest bed is Moustérien (P. 65–75), the next two Solutréen (P. 75–85, l. 30; and, say, l. 50 or 60), the succeeding four Magdalénien (P. 85–95, l. 30, l. 40, l. 50, and l. 60), and the uppermost Neolithic.[2]

Turning again to the High Down Drift of the Isle of Wight: in my earlier work here I was rather puzzled with the implements from the "layer of stones" already mentioned. Some of them, those of classes A and B, were clearly derived. Others, those of class D, were as clearly contemporary; and, as I afterwards found, some of the flakes were lying close to the cores from which they had been struck off, several of which I have been able to replace. But a certain number of the implements, those of class C, were not quite in accordance with either of the foregoing classes. These were somewhat ochreous for the most part; they seemed to be derived, and yet they were not much abraded, and not in the least corroded or deeply altered as those of classes A and B. They seemed to be intermediate between the two extreme forms, and yet, having in mind at that time rather an idea of 'epochs' than the idea of 'sequence dates,' I hesitated to refer them to an intermediate age. But that they are of intermediate age I have now no doubt, and last Summer I found a broken pointed implement that went far to confirm my opinion. A portion of the butt of this specimen shows a natural fracture in the earliest, corroded, condition. This is cut across by the working of the implement. The worked surface, though it shows a section of the earlier patina, is itself a little abraded and slightly altered; the point of the implement being broken off by what, if I am not mistaken, is a still later fracture, contemporary with the unaltered implements. Thus, in addition to the numerous implements, and still more numerous unworked flints, which show two out of the three main conditions, I at last found all these conditions, marked off from each other, upon the same implement.

If my conclusions are sound, then, and the implements of class C are derived, those of classes A and B must be twice derived. It would be exceedingly difficult to show from the specimens themselves that the brown corroded flints of class A had been twice derived, but an examination of those of class B brings to light certain facts that point in that direction. Among these (class B) there is a rude outer flake with large *éraillure*. The surface of this is much corroded and abraded, and shows the white patina caused by weathering. Beneath this whitening there is seen, on the

[1] A. de Maret: "Fouilles de la grotte du Placard, près de Rochbertier"; Tours, 1879. G. de Mortillet: "Musée Préhistorique," 1881, pl. xxix.

[2] Professor Flinders Petrie begins his local scale at 30, in order to allow for future discoveries, and it is as well to carry out that system uniformly, wherever it may be possible to do so.

broken edges, an earlier ochreous staining. All round the edges there are abrasions which are later than the whitening, these later abrasions being in condition B. Thus we see that this flake lay for a long period on the surface, exposed to the influences of the atmosphere, between the time of an earlier ochreous staining (almost certainly preceded by abrasion) and a later abrasion. It seems most probable that when these flints of class B were washed out of their early drift and exposed on the surface, those of class A were also washed out of that first drift and embedded in a second, to be again re-drifted and buried together in the present drift, mingled with contemporary implements. The later abrasions of class B are very possibly contemporary with the implements of class C, but I do not like to force the evidence too far. What has been said is enough to show what a long history of successive abrasions these early implements have suffered; and further, by careful attention to their condition, that it is possible, in some measure at least, to read what that history has been.

I should hesitate, from the material at my disposal, to class either of these three ages as of either Acheuléen or Moustérien or of any other epoch. But by an examination of their style of workmanship and their types, one can easily fix their position, within certain broad limits, in the 'sequence date' scale. The rude ovate and other implements of the oldest series fall into the scale at P. 30–45; the next series at P. 45–65; while the latest implements consist of the waste product of a workshop, spalls, cores, and 'wasters' or *ébauches*, from which little can safely be inferred. They seem to come in at P. 65–80, but as they are ill-defined it is better to class them as P. 60–99.

It may be worth while to mention, in passing, that calcined flints are not uncommon in this layer of stones. There can be no doubt that these were burnt by the fires lighted by the Palæolithic men who made the latest of these implements.

In another layer of stones,[1] above the one I have been dealing with, there are other implements. The number I have is not very large, but they include: ochreous, abraded, derived forms, apparently about P. 30–50; ochreous, almost unabraded implements of skilful workmanship, evidently drifted, but from no great distance, apparently P. 60–70; together with a few flakes and cores, contemporary (quite unabraded) and whitened in condition, which may very probably be Palæolithic, but about whose exact position in the drift I am uncertain. At present, at least, they are of no particular interest.

It sometimes happens that an implement not only shows later accidental fractures which are contemporary with another series of implements, but even a later working. These re-worked examples have been recorded by many observers, and I have a good example from Santon Downham, Suffolk, near Thetford, to which locality I shall refer again towards the end of this paper.

Flints may become chipped, through movements of the soil,

[1] Geol. Mag., September, 1900, p. 407.

while they lie in place in their beds, and these chips will then be no evidence of derivation. This possibility of error must be carefully guarded against. Chipping produced in this way has, in general, certain characters by which it may be distinguished, as I hope to show very shortly. And, in addition, if these chips were made in the bed in which the flint lay up to the time it was discovered, they will not be abraded and water-worn as they are when the flint is truly derived.

To satisfy the requirements of clear proof, these contemporary and derived implements must have been buried together in a bed of proved age. With regard to Palæolithic implements found on the surface of the ground, little can be inferred as to their relative age; except, more or less doubtfully according to circumstances, by a comparison of their types with those where stratigraphical evidence is obtainable. The evidence of later fractures on patinated flints is obviously inapplicable to implements found on the surface, for the age of these later fractures cannot be ascertained, except, perhaps, in cases of re-working. But where a variety of implements are found together on the surface, and the deeply patinated forms are uniformly of Palæolithic type, while those not so patinated are of Neolithic type, I think one may be perfectly safe in referring the former to some part of the Palæolithic Period.

Sir Henry Howorth,[1] in a recent number of this Magazine, has referred to Dr. H. O. Forbes'[2] unfavourable conclusions as to the presumed Palæolithic age of certain Egyptian implements. But one cannot feel assured that the *ébauches* or 'wasters' of the comparatively recent flint workshops, even though some of them are of Palæolithic form and much patinated, are really the same as the presumed Palæolithic implements spread over the surface of the desert. Such old forms occur also in company with Neolithic remains in England. One can only judge the age of surface implements by the facies of a considerable number that appear to be in undoubted association with each other. And so far as one may judge from the accounts of those who have collected in the district, the general facies of the implements in dispute is pretty clearly Palæolithic.

The Evidence of Mineral Condition applied to the River Drifts.

Almost everywhere where Palæolithic implements have been collected with sufficient care, stratigraphical evidence, in one form or another, is forthcoming to indicate differences in age and a certain definite succession.

If we turn to the so-called high-level gravels of our river valleys, we find, for instance, at Stoke Newington:[3] a derived series, often, but not always, with an ochreous patina (P. 30–40); a series abraded to some extent, but not derived (P. 55–60); and an

[1] Geol. Mag., August, 1901, pp. 337–344.
[2] Bull. Liverpool Museums, 1900, vol. ii, pp. 77–115; 1901, vol. iii, pp. 48–61.
[3] Worthington G. Smith: "Man the Primeval Savage," 1894, p. 189 et seq.

unabraded contemporary series (P. 65–75), confined to a definite horizon (the 'Palæolithic Floor'), above that of the earlier implements. Thus we see that at the time P. 65–75 the implements of P. 30–40 held very much the same position in those river gravels which Palæolithic implements generally hold in our modern river gravels; while the intermediate series (P. 55–60) were being rolled about in the bed of the river, then swifter and broader than at present, just as Neolithic implements are lying in the beds of our rivers to-day.

At the 'high-level terrace' of Saint-Acheul, near Amiens, again, we find: a derived series (P. 30–50, probably P. 30–40); perhaps an early contemporary series at the base of the deposit (? P. 40–55); an unabraded and contemporary series in the middle beds (P. 60); while another contemporary unabraded series occurs in the brickearth above (P. 65–75). There are also others (P. 60–80) in the lower drifts of Menchecourt, etc., and, as already mentioned, perhaps still later forms (? P. 75–90) in the later brickearths.

I will refer to only one other district—one where the phenomena are widely different from either Stoke Newington or Saint-Acheul—and that is the country around Thetford and Mildenhall.[1] Here there is, first, the high-level terrace of Brandon Down and Lakenheath, which is unconnected with the present river system. These gravels yield implements (P. 30–50) which often seem to have been derived from the surface soil of the period rather than from an earlier drift, together with contemporary forms (P. 50–65). Below these high-level gravels there are, in the present valleys of the Little Ouse and the Lark, the deposits of High Lodge, near Mildenhall, and Santon Downham, near Thetford, yielding contemporary implements (P. 65–75); while at various levels below these, in the same valleys, there are the gravels of Warren Hill, near Mildenhall, Redhill, near Thetford, Shrub Hill, in the parish of Feltwell, and other places, containing a mixture of derived implements of various ages (P. 30–75), together with a certain proportion of contemporary implements (P. 75–99), especially at Shrub Hill. Some of these last implements are of the usual Palæolithic types, some remind one of the ruder forms of the Neolithic Period, while others are almost counterparts of the surface implements, of somewhat uncertain age, from the Plateau of Leugny (Vienne) and other places in Poitou and Brittany.

Conclusion.

Although it is perfectly true that no conclusions can be drawn either from mere rudeness of workmanship in individual specimens, or from a few implements chancing to have, or not to have, an ochreous patina, yet I am confident that it is from such evidence as is indicated in this paper, that the more detailed history of early man must be read.

[1] The best general account of this district is to be found in Sir John Evans' "Ancient Stone Implements," 1897, 2nd ed., pp. 543–572.

II.—On an *Alveolina*-Limestone and Nummulitic Limestones from Egypt.

By Frederick Chapman, A.L.S., F.R.M.S.

Part II.

(Plates IV and V.)

FORAMINIFERA.

MILIOLINA, Williamson [1858].

Miliolina inflata (d'Orbigny).

Triloculina inflata, d'Orbigny, 1846: Foram. Foss. Vienne, p. 278, pl. xvii, figs. 13–15.

This species is fairly common in the *Alveolina*-limestone of the present series, occurring both in the powdered rock and in thin sections. For the previous occurrences of the species in Egypt see Geol. Mag., 1900, p. 7.

Nos. 3,335*b* and *c*. Farafra Oasis: Libyan Series.

Miliolina trigonula (Lam.).

M. trigonula (Lam.), Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 86, pl. xxiv (i), figs. 6*a–d*. Chapman, 1900: Geol. Mag., p. 6.

A single specimen, rather quinqueloculine than trigonuline in contour, was isolated from the *Alveolina*-limestone.

No. 3,335*b*. Farafra Oasis: Libyan Series.

ALVEOLINA, d'Orbigny [1826].

Alveolina ellipsoidalis, Schwager.

Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 96, pl. xxv (ii), figs. 1*a–i*, 2*a–c*. Chapman, 1900: Geol. Mag., p. 8.

This species was described by Schwager from Dr. Schweinfurth's specimens which the latter obtained from Wadi Natfe. It has also been found by the writer in *Patellina*-limestone from a locality between Cairo and Suez. This present occurrence seems to support the idea which Blanckenhorn has already advanced,[1] that the rock which yielded *Patellina* is of earlier date than Miocene, to which it was thought referable, though with some reservation. In the present series *A. ellipsoidalis* is somewhat rare.

Farafra Oasis. Nos. 3,335*b* and *c*. Libyan Series.

Alveolina decipiens, Schwager.

Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 103, pl. xxvi (iii), figs. 1*a–k*.

This form is easily recognized among the separated specimens by its large size. In shape it is ellipsoidal, but with blunt ends. Internally it is distinguished from *A. pasticillata* by the shape of the septal canals.

Frequent. Specimens 3,335*b* and *c*. Farafra Oasis: Libyan Series.

[1] Zeitschr. deutsch. geol. Gesellsch., 1900, p. 431.

ALVEOLINA DECIPIENS, var. DOLIOLIFORMIS, Schwager.

Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 103, pl. xxv (ii), figs. 7*a–g*.

A few isolated specimens of this variety were noted among the other *Alveolinæ*. It has the test sunken in the umbilical centres.

Specimens 3,335*b* and *c*. Farafra Oasis : Libyan Series.

ALVEOLINA PASTICILLATA, Schwager.

Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 104, pl. xxvi (iii), figs. 2*a–h*.

This rotund species is by far the commonest in our collection of *Alveolinæ*. It was previously recorded from Wadi Natfe, Nekeb-el-Farudj, and El-Guss-Abu-Said, by Schwager.

Very abundant. Specimens 3,335*b* and *c*. Farafra Oasis: Libyan Series.

PLACOPSILINA, d'Orbigny [1850].

PLACOPSILINA CENOMANA, d'Orbigny. (Pl. V, Fig. 4.)

D'Orbigny, 1850: Prodrome Paléont., vol. ii, p. 185, No. 758. Brady, 1884: Rep. Chall., vol. ix, p. 315, pl. xxxvi, figs. 1–3.

The occurrence of the present specimen is of considerable interest, since the species has never been recorded from Tertiary beds, although it is a well-known form in deposits of Cretaceous age as well as those of recent date.

One small but perfect specimen, attached to a shell-fragment. Specimen 3,335*b*. Farafra Oasis : Libyan Series.

TEXTULARIA, Defrance [1824].

TEXTULARIA, sp. near GRAMEN, d'Orbigny.

T. gramen, d'Orb., 1846: Foram. Foss. Vienne, p. 248, pl. xv, figs. 46.

This genus is here represented by a single specimen, seen in section, from the limestone of the Baharia Oasis. Its outline is like that of *T. gramen*, but we cannot be quite certain of the species, since no other sections were seen, nor specimens isolated from the rock. None of the examples of *Plecanium* figured by Schwager quite match our specimen.

No. 1,480*e*. Plateau west of Baharia Oasis: Lower Mokattam Series.

VALVULINA, d'Orbigny [1826].

VALVULINA SCHWAGERI, sp. nov. (Pl. V, Figs. 5*a–d*.)

Clavulina sp., Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, pl. xxvi (iii), figs. 19*a*, *b*.

Test triserial, triangular in outline, consisting of about five series of chambers arranged as in *Verneuilina*. The angles of the test slightly rounded, the faces slightly concave. Aperture valvuline, seen more distinctly in section than in the isolated specimens. Length, 1·1 mm.; greatest breadth, ·8 mm.

This form has already been figured by Schwager and referred to as *Clavulina* sp., but no specific name was assigned to it.

The sections of this species are numerous in the thin slices of the Farafra limestone. It was from this particular rock that Schwager obtained his examples.

Specimens 3,335*b* and *c*. Farafra Oasis : Libyan Series.

BULIMINA, d'Orbigny [1826].

Bulimina elegantissima, d'Orb., var. seminuda, Terquem. (Pl. V, Figs. 5*a*, *b*.)

Bulimina seminuda, Terquem, 1882 : Mém. Soc. géol. France, ser. III, vol. ii, Mém. iii, p. 117, pl. xii, fig. 21.

B. elegantissima, d'Orb., var. *seminuda*, Terquem, Brady, 1884 : Rep. Chall., vol. ix, p. 403, pl. L, figs. 23, 24.

Terquem's specimens came from the Eocene of the Paris Basin. The recent examples are most typical from shallow water.

This species is represented in the series now described by a single example, slightly more crispate in form, but otherwise typical. This is its first occurrence in the Egyptian Eocene.

No. 3,335*b*. Farafra Oasis : Libyan Series.

Globigerina bulloides, d'Orbigny.

D'Orbigny, 1826 : Ann. Sci. Nat., vol. vii, p. 277, No. 1 ; Modèles, Nos. 17 and 76. Schwager, 1883 : Palæontographica, vol. xxx, Pal. Theil, p. 118, pl. xxvii (iv), figs. 5*a–c*.

The whole of the present material has yielded only one specimen of the above form ; Schwager's examples also came from the Mokattam Series.

No. 1,480*e*. Plateau west of Baharia Oasis : Lower Mokattam Series.

Globigerina cretacea, d'Orbigny.

D'Orbigny, 1840 : Mém. Soc. géol. France, vol. iv, p. 34, pl. iii, figs. 12–14.

This species is not uncommon in sections of the Lower Libyan limestone ; it is possibly derived from Cretaceous beds.

No. 1,531*f*. North of Mendische, Baharia Oasis : Libyan Series.

DISCORBINA, Parker & Jones [1862].

Discorbina parisiensis (d'Orbigny).

Rosalina parisiensis, d'Orbigny, 1826 : Ann. Sci. Nat., vol. vii, p. 271, No. 1 ; Modèles, No. 38.

Pulvinulina cf. *campanella*, Gümbel, Schwager, 1883 : Palæontographica, vol. xxx, Pal. Theil, p. 131, pl. xxviii (v), figs. 3*a–d*.

Schwager's figure appears to be that of a discorbine form, and one of our specimens exactly matches it. There is little doubt as to its relationship with the *Rosalina parisiensis* of d'Orbigny.

Nos. 3,335*b* and *c*. Farafra Oasis : Libyan Series.

TRUNCATULINA, d'Orbigny [1826].

Truncatulina candidula (Schwager).

Pulvinulina candidula, Schwager, 1883 : Palæontographica, vol. xxx, Pal. Theil, p. 133, pl. xxviii (v), figs. 10*a–d*.

A specimen of the above occurs in our Upper Libyan (*Alveolina*) limestone. Schwager's specimens, however, came from the

Mokattam Series of Aradj and Turra near Cairo. The fact that the shell-texture is distinctly porous, as is also stated by Schwager, shows that the species properly belongs to *Truncatulina* and not to *Pulvinulina*.

Nos. 3,335*b* and *c*. Farafra Oasis : Libyan Series.

TRUNCATULINA UNGERIANA (d'Orbigny).

Rotalia Ungeriana, d'Orbigny, 1846 : Foram. Foss. Vienne, p. 157, pl. viii, figs. 16–18.

Pulvinulina mokattamensis, Schwager, 1883 : Palæontographica, vol. xxx, Pal. Theil, p. 134, pl. xxviii, figs. 11*a–d*.

This widely distributed species is quite common in the *Alveolina*-limestone of Farafra. It is a well-known form in all Tertiary deposits.

Nos. 3,335*b* and *c*. Farafra Oasis : Libyan Series.

AMPHISTEGINA, d'Orbigny [1826].

AMPHISTEGINA LESSONII, d'Orbigny.

A. Lessonii, d'Orb., 1826 : Ann. Sci. Nat., vol. vii, p. 304, No. 3, pl. xvii, figs. 1–4 ; Modèles, No. 98.

The sample of limestone from Wadi Dara, east of the Red Sea Hills, contains many specimens of *A. Lessonii* associated with large *Heterosteginæ*. The former are somewhat flat varieties of the species, and but for their inequilateral shape when cut through the umbonal axis, might almost be mistaken for small nummulites as *N. variolaria*.

No. 2,195, 1*h*. Wadi Dara, east of Red Sea Hills : Miocene.

OPERCULINA, d'Orbigny [1826].

OPERCULINA COMPLANATA (Defrance), var. CANALIFERA, d'Archiac.

O. libyca, Schwager, 1883 : Palæontographica, vol. xxx, Pal. Theil, p. 142, pl. xxix (vi), figs. 2*a–g*.

O. complanata (Defr.), var. *canalifera*, d'Archiac, Chapman, 1900 : GEOL. MAG., p. 7, Pl. XIII, Figs. 3*a*, 4*a* ; Pl. XIV, Fig. 12.

This variety is met with in two of the samples, which are both from the Baharia Oasis. The length of the largest specimen is 9·5 mm.

No. 1,531*f*. North of Mendische, Baharia Oasis : very abundant : Lower Eocene : Libyan Series. Also No. 3,348*g*, N.N.W. of Bawitti, Baharia Oasis ; a few scattered and broken specimens. Lower Eocene : Libyan Series.

OPERCULINA COMPLANATA (Defrance), var. DISCOIDEA, Schwager.

O. discoidea, Schwager, 1883 : Palæontographica, vol. xxx, Pal. Theil, p. 145, pl. xxix (vi), figs. 5*a–d*.

O. complanata (Defr.), var. *discoidea*, Schwager, Chapman, 1900 : GEOL. MAG., p. 8, Pl. XIV, Fig. 13.

In cross-section this variety is easily distinguished from the preceding form by the very pronounced septal ridges which stand out prominently from the lateral shell-surface.

West of Bawitti, on plateau west of Baharia Oasis, No. 1,480*e*. Common. Middle Eocene : Lower Mokattam Series.

Operculina complanata (Defr.), var. pyramidum, Ehrenberg, var.

Planulina pyramidum, Ehrenberg, 1838: Abhandl. k. Wiss. Berlin, p. 93, pl. iv, fig. 7.

Operculina pyramidum (Ehr.), Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 143, pl. xxix (vi).

From a zoological standpoint this variety is fairly comparable with *granulosa* of Leymerie, but since it shows some little differences from the strongly beaded form just named, in having a somewhat neater test, we may perhaps retain for the Egyptian specimens the name which Ehrenberg gave. It is easily separated from the two preceding in thin sections of the rock, by its having a thicker test, and the secondary bead ornamentation along the septal ridges.

No. 3,535, 52*l*. North of Salamuni, between Assiut and Qena, east side of Nile. Common. Lower Eocene: Upper Libyan Series.

HETEROSTEGINA, d'Orbigny [1826].

Heterostegina depressa, d'Orbigny.

H. depressa, d'Orbigny, 1826: Ann. Sci. Nat., vol. vii, p. 305, No. 2, pl. xvii, figs. 5–7; Modèles, No. 99. Chapman, 1900: Geol. Mag., p. 8, Pl. XIII, Fig. 7*a*.

This is an extremely abundant form in one of the limestones, where it is represented by some thin, large, flexuose tests (2,195, 1*h*), frequently measuring 7 mm. in diameter. The second occurrence is in the *Alveolina*-limestone (3,335*b* and *c*), and there we have met with only one example, probably a young individual, closely resembling d'Orbigny's *Heterostegina simplex* of the Vienna Tertiaries.

Specimen 2,195, 1*h*. Two kilometres north-west of Camp 49, Wadi Dara, east of Red Sea Hills. Miocene.

Specimens 3,335*b* and *c*. Western wall of depression, Farafra Oasis. Lower Eocene: Libyan Series.

NUMMULITES, Lamarck [1801].

Nummulites Biarritzensis, d'Archiac, var. præcursor, De la Harpe.

De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 170, pl. xxx (i), figs. 21–28.

The variety is more compressed than the type, and has generally a sharper edge. The central chamber is almost invisible. De la Harpe described this variety from the grey marl of the lower Libyan Series east and west of Farafra.

Nos. 3,335*b* and *c*. *Alveolina*-limestone, from western wall of depression, Farafra Oasis. Rather rare. Lower Eocene: Libyan Series.

Also doubtfully from specimen 3,348*g*. Eight kilometres N.N.W. of Bawitti, Baharia Oasis. Lower Eocene: Libyan Series.

Nummulites Guettardi, d'Archiac & Haime, var. antiqua, De la Harpe.

De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 172, pl. xxx (i), figs. 37–42. Chapman, 1900: Geol. Mag., p. 10, Pl. XIII, Fig. 6*b*.

The only occurrence for this variety in the present series is in the much altered and recrystallized limestone from the Baharia Oasis.

Specimen 3,348*g*. Eight kilometres N.N.W. of Bawitti, Baharia Oasis. Frequent. Lower Eocene: Libyan Series.

NUMMULITES RAMONDI, Defrance.

N. Ramondi, Defrance, 1825: Dict. Sci. Nat., vol. xxxv, p. 224. Chapman, 1900: GEOL. MAG., p. 10, Pl. XIII, Figs. 3*b*, 4*b*.

Specimen No. 1,531*f*. Eight kilometres north of Mendische, Baharia Oasis. Common. Lower Eocene: Libyan Series.

NUMMULITES VARIOLARIA (Lamarck).

N. variolaria (Lam.), De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 179, pl. xxxi (ii), figs. 28–36. Chapman, 1900: GEOL. MAG., p. 11, Pl. XIII, Fig. 2*b*.

This species is one of the commonest in the present series of limestones in the two samples quoted below. Some of the specimens are very small, measuring as little as 1 mm. in diameter. They are well characterized by the large central chamber, and usually have from three to four turns to the shell.

Specimen 2,195, 1*h*. Two kilometres north-west of Camp 49, Wadi Dara, east of Red Sea Hills. Common. Miocene.

Specimen 1,531*f*. Eight kilometres north of Mendische, Baharia Oasis. Very common. Lower Eocene: Libyan Series.

NUMMULITES BEAUMONTI, d'Archiac.

De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 180, pl. xxxi, figs. 37–47.

Our largest specimens exceed the measurement given by De la Harpe by ·5 mm., and a fair number attain his maximum diameter of 12 mm. The distinctive characters of this form are, when seen externally, the medium thick test, evenly lenticular or slightly flexuose in edge view, and the shell surface marked with fine radial lines. The test is from 4 to 12 mm. or more in diameter, and from 2 to 4 mm. thick; the whorls number, according to De la Harpe, twelve to thirteen on a radius of 4 mm. and sixteen on a radius of 7 mm.

It has been recorded from the Mokattam, Wadi-el-Tih, near Heluan, on the Jebel Achmar, on the pyramids of Gizeh; also between the Nile Valley and the Farafra, Baharia, and Siuah Oases.

Specimen 3,535, 52*l*. North of Salamuni, between Assiut and Qena, east side of Nile. Common. Lower Eocene: Upper Libyan Series.

Specimen 1,516*h*. 17 kilometres N.N.E. of Ain-el-Haiss, Baharia Oasis. Abundant. Middle Eocene: Lower Mokattam Series.

NUMMULITES SUB-BEAUMONTI, De la Harpe.

N. sub-Beaumonti, De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 182, pl. xxxi (ii), figs. 48–56.

This form is associated with the preceding, and occurs in the two samples before quoted, namely, specimens 3,535, 52*l*, and 1,516*h*. It is smaller than *N. Beaumonti*, measuring $1\frac{1}{2}$ to 5 mm., and it is stouter in comparison, being from 1 to $2\frac{1}{2}$ mm. thick.

NUMMULITES DISCORBINA, Schlotheim.

Lenticulites discorbina, Schlotheim, 1820 : Petrefactenkunde, p. 89.
Nummulites discorbina (Schlotheim), De la Harpe, 1883 : Palæontographica, vol. xxx, Pal. Theil, p. 183, pl. xxxii (iii), figs. 1–7.

A small nummulite with a thick, rounded test, and numerous whorls (maximum fourteen on a radius of 4 mm.). Usually associated with *N. Beaumonti* and allied forms, although our samples prove an exception.

Specimen 1,480*e*. West of Bawitti, on plateau west of Baharia Oasis. Common. Middle Eocene : Lower Mokattam Series.

NUMMULITES SUBDISCORBINA, De la Harpe.

N. subdiscorbina, De la Harpe, 1883 : Palæontographica, vol. xxx, Pal. Theil, p. 185, pl. xxxii (iii), figs. 8–15. Chapman, 1900 : GEOL. MAG., p. 11, Pl. XIII, Fig. 1.

Specimen 1,480*e*. West of Bawitti, on plateau west of Baharia Oasis. Frequent. Middle Eocene : Lower Mokattam Series.

NUMMULITES GIZEHENSIS (Forskål), Ehrenberg, var. PACHOI, De la Harpe.

N. Gizehensis var. *Pachoi*, De la Harpe, 1883 : Palæontographica, vol. xxx, Pal. Theil, p. 193, pl. xxxiii (iv), figs. 14–18 ; pl. xxxiv (v), figs. 1–5. Chapman, 1900 : GEOL. MAG., p. 12.

This variety has already been recorded from the Baharia Oasis by De la Harpe. It occurs in the present series in two samples from the same locality, namely, specimens 1,467*d* and 1,480*e*, 39 kilometres west of Bawitti, on plateau west of Baharia Oasis. Common. Middle Eocene : Lower Mokattam Series.

NUMMULITES CURVISPIRA, Savi & Meneghini.

Nummulina curvispira, Savi & Meneghini, 1851 : Consid. Geol. Toscana, p. 137.
N. curvispira (Menegh.), De la Harpe, 1883 : Palæontographica, vol. xxx, Pal. Theil, p. 200, pl. xxxiv (v), figs. 42–67. Chapman, 1900 : GEOL. MAG., p. 13, Pl. XIII, Fig. 5.

Typical specimens of the above were found in four of the samples of the present collection. In that from Jebel Hamrawen this species forms a large proportion of the rock, and is near the normal size, measuring 1·5 mm. in diameter.

Specimens 1,622, 56*h*, and 1,622, 6*k*, under Eocene nodular bed near Jebel Hamrawen. Very abundant.

Specimen 1,467*d*. 39 kilometres west of Bawitti, on plateau west of Baharia Oasis. Common.

Specimen 1,480*e*. Same locality. Occasional. Middle Eocene : Lower Mokattam Series.

ORBITOIDES, d'Orbigny [1847].

ORBITOIDES (DISCOCYCLINA) DISPANSA (Sowerby).

Lycophris dispansus, Sowerby, 1837 [1840] : Trans. Geol. Soc. Lond., ser. II, vol. v, pp. 327, 718, pl. xxiv, figs. 16, 16*a*, *b*.

It appears that this species has not been recorded before from the Baharia Oasis.

Specimen 1,480*e*. West of Bawitti, on plateau west of Baharia Oasis. Very rare. Middle Eocene : Lower Mokattam Series.

SECTIONS OF EOCENE FORAMINIFERAL LIMESTONES FROM EGYPT.

SPECIES MENTIONED IN THIS PAPER.

1. *Bairdia subdeltoidea* (Münster). Eocene: Farafra Oasis.
2. *B. Beadnelli*, sp. nov. Eocene: Farafra Oasis.
3. *B. minuta*, sp. nov. Eocene: Farafra Oasis.
4. *Cythere Farafrensis*, sp. nov. Eocene: Farafra Oasis.
5. *Miliolina inflata* (d'Orb.). Eocene: Farafra Oasis.
6. *M. trigonula* (Lam.). Eocene: Farafra Oasis.
7. *Alveolina ellipsoidalis*, Schwager. Eocene: Farafra Oasis.
8. *A. decipiens*, Schwager. Eocene: Farafra Oasis.
9. *A. decipiens*, var. *dolioliformis*, Schwager. Eocene: Farafra Oasis.
10. *A. pasticillata*, Schwager. Eocene: Farafra Oasis.
11. *Placopsilina cenomana*, d'Orb. Eocene: Farafra Oasis.
12. *Textularia*, sp. near *gramen*, d'Orb. Eocene: Baharia Oasis.
13. *Valvulina Schwageri*, sp. nov. Eocene: Farafra Oasis.
14. *Bulimina elegantissima*, d'Orb., var. *seminuda*, Terquem. Eocene: Farafra Oasis.
15. *Globigerina bulloides*, d'Orb. Eocene: Baharia Oasis.
16. *G. cretacea*, d'Orb. Eocene: Baharia Oasis.
17. *Discorbina parisiensis* (d'Orb.). Eocene: Farafra Oasis.
18. *Truncatulina candidula* (Schwager). Eocene: Farafra Oasis.
19. *T. Ungeriana* (d'Orb.). Eocene: Farafra Oasis.
20. *Amphistegina Lessonii*, d'Orb. Miocene: east side of Red Sea Hills.
21. *Operculina complanata* (Defr.), var. *canalifera*, d'Archiac. Eocene: Baharia Oasis.
22. *O. complanata* (Defr.), var. *discoidea*, Schwager. Eocene: Baharia Oasis.
23. *O. complanata* (Defr.), var. *pyramidum* (Ehr.). Eocene: between Assiut and Qena, east side of Nile.
24. *Heterostegina depressa*, d'Orb. Eocene: Farafra Oasis. Miocene: east of Red Sea Hills.
25. *Nummulites Biarritzensis*, d'Archiac, var. *præcursor*, De la Harpe. Eocene: Baharia and Farafra Oases.
26. *N. Guettardi*, d'Archiac & Haime, var. *antiqua*, De la Harpe. Eocene: Baharia Oasis.
27. *N. Ramondi*, Defr. Eocene: Baharia Oasis.
28. *N. variolaria* (Lam.). Eocene: Baharia Oasis.
29. *N. Beaumonti*, d'Archiac. Eocene: Baharia Oasis; and between Assiut and Qena, east side of hill.
30. *N. sub-Beaumonti*, De la Harpe. Eocene: Baharia Oasis; and between Assiut and Qena, east side of hill.
31. *N. discorbina*, Schlotheim. Eocene: Baharia Oasis.
32. *N. subdiscorbina*, De la Harpe. Eocene: Baharia Oasis.
33. *N. Gizehensis* (Forskål), Ehr., var. *Pachoi*, De la Harpe. Eocene: Baharia Oasis.
34. *N. curvispira*, Savi & Menegh. Eocene: Jebel Hamrawein and Baharia Oasis.
35. *Orbitoides* (*Discocyclina*) *dispansa* (Sow.). Eocene: Baharia Oasis.

EXPLANATION OF PLATE IV.

Fig. 1.—*Heterostegina*-limestone (*H. depressa*). Miocene: Wadi Dara, east of Red Sea Hills. No. 2,195, 1*h*. × 16.

Fig. 2.—Nummulitic limestone (*N. curvispira*). Mokattam Series: near Jebel Hamrawein, east of Red Sea Hills. No. 1,622, 56*h*. × 16.

Fig. 3.—*Operculina*- and nummulitic limestone (showing *O. complanata* var. *pyramidum* and *N. sub-Beaumonti*). Eocene: between Assiut and Qena, east side of Nile. No. 3,535, 52*l*. × 16.

Fig. 4.—Nummulitic and *Operculina* limestone (showing *N. discorbina*, *N. subdiscorbina*, and *O. complanata* var. *discoidea*). Eocene. No. E 1,480. × 16.

Fig. 5.—*Alveolina*-limestone (showing *Alveolina pasticillata* and *Valvulina Schwageri*). Eocene: Farafra Oasis (El-Guss-Abu-Said). No. 3,335*c*. × 16.

Fig. 6.—Nummulitic limestone with cavities filled with calcite, which were formerly occupied each by a nummulite. Eocene: Baharia Oasis. No. 3,348*g*. × 8.

EXPLANATION OF PLATE V.

FIG. 1.—*Bairdia Beadnelli*, sp. nov. *a*, view from right side; *b*, edge view; *c*, end view. Farafra Oasis. No. 3,335*b*. × 15.

FIG. 2.—*Bairdia minuta*, sp. nov. *a*, view from left side; *b*, edge view; *c*, end view. Farafra Oasis. No. 3,335*b*. × 15.

FIG. 3.—*Cythere Farafrensis*, sp. nov. *a*, view from left side; *b*, edge view; *c*, end view. Farafra Oasis. No. 3,335*b*. × 30.

FIG. 4.—*Placopsilina cenomana*, d'Orb. Farafra Oasis. No. 3,335*b*. × 30.

FIG. 5.—*Valvulina Schwageri*, sp. nov. *a*, the isolated test, lateral view; *b*, *c*, sections in vertical direction; *d*, transverse oral section. Farafra Oasis. Nos. 3,335*b* and *c*. × 30.

FIGS. 6*a*, *b*.—*Bulimina elegantissima*, d'Orb., var. *seminuda*, Terquem. Farafra Oasis. No. 3,335*b*. × 30.

III.—On Kent's Cavern with reference to Buckland and his Detractors.

By Arthur R. Hunt, M.A., F.L.S., F.G.S.

IN the Geological Magazine for September, 1901, I pointed out that Sir Henry Howorth had done Professor Huxley a great injustice in charging him with having suppressed certain important evidence. In the Magazine for January, 1902, Sir Henry, instead of hastening to acknowledge his error, proceeds to deepen his guilt by joining the pack that yelps at the heels of the great Dean Buckland.

The one object of Buckland and the old cave-hunters was to reject a hundred facts rather than risk the acceptance of one error. Sir Henry shows clearly by his article that he would readily accept a hundred fallacies rather than run the risk of missing one fact. Let us take his three cases of Burrington, Wookey Hole, and Paviland, for each of which he censures Buckland, implicitly if not explicitly, e.g.—

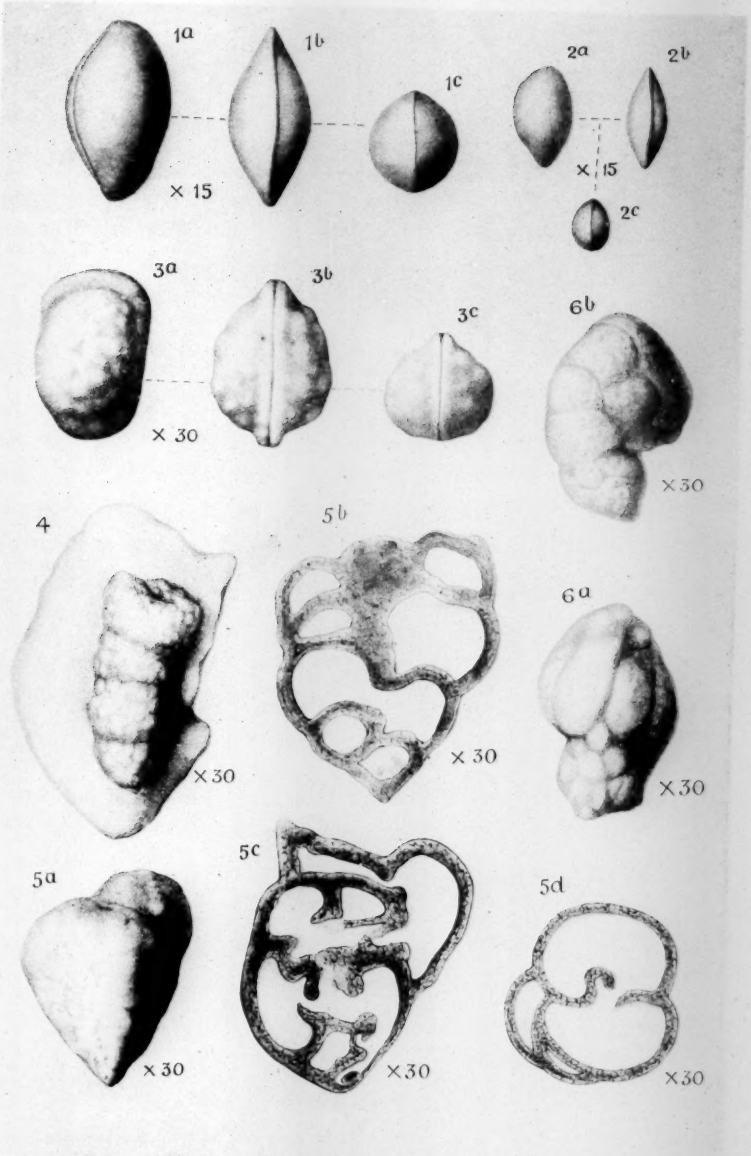
Burrington. This is a cave in the Mountain Limestone with its mouth nearly closed by 'stalactite.' In it were bones encrusted by 'stalactite,' merely encrusted, not enclosed.[1] Sir Henry remarks, "It seems from our present knowledge almost certain that these bones belonged to Palæolithic man."

Some years ago, when exploring a cave on the coast of Galloway, my colleagues and self were desperately perplexed by portions of a human skull found under a mass of some 18 inches of stalagmitic breccia, capped by 2½ feet of practically pure stalagmite. Mr. W. Bruce Clarke, who wrote the final report on the cave, was inclined to dismiss the stalagmite as of no great importance, but kindly allowed me to record my dissent from that conclusion.[2] But the very utmost I could urge would be the time that has elapsed since the coastline has remained at its present level, as the cave seems to be a sea-cave of the existing period!

Our skull, under some four feet of breccia and stalagmite, was certainly not Palæolithic, and probably the merely encrusted Burrington bones were still more modern.

[1] Reliquiæ Dil., p. 164.

[2] Proc. Soc. Ant. Scot., 1878, p. 677.



OSTRACODA AND FORAMINIFERA FROM EOCENE LIMESTONES, EGYPT.

Among my notes collected during the exploration of the Borness Cave are the following extracted from the Proc. Soc. Ant., vol. iv, p. 111 :—

"Dowkerbottom Cave is on the high ground between Arncliffe and Kilnsay. . . . One of the coins found was under six inches of stalagmite. At this point the stalagmite was between five and six feet in thickness ; it was in layers, occasionally very hard, and then quite rotten and decayed. Some of the bones were buried deep in the stalagmite. . . . Three human crania in the cave . . . Goat, Dog, Horse."

This information is not precise enough for scientific purposes, and we are not even told the age of the coin. But we learn incidentally that the three coins found were of the reigns of Tetricus, A.D. 267–273, and of Claudius Gothicus, whose reign terminated in A.D. 270. These dates harmonized well with the main collection from the Borness Cave, though in my opinion the skull under the four feet of stalagmitic deposit must be much older, though assuredly not Palæolithic. According to Sir Henry Howorth's reasoning, we should have to accept both Claudius and Tetricus as Palæolithic men, and coinage as a Palæolithic art.

Wookey Hole. Here the teeth and fragments of bone were dispersed through reddish mud and clay, and some of them were united to it by stalagmite into a firm osseous breccia.[1] Sir Henry observes that as Buckland found a piece of a sepulchral urn among the bones, "this case is a doubtful one." Doubtful! What could be more certain ?

Paviland. Sir Henry tells us that in this cave a female skeleton was found beneath six inches of earth, associated with two handfuls of shells of *Nerita littoralis* ; by which shell Buckland undoubtedly means *Littorina littoralis,* as he says it is common on the adjacent shore. Sir Henry continues, "We can hardly doubt with our present knowledge that these bones were those of a Palæolithic woman." On the contrary, Sir John Evans considers them those of a Neolithic man.[2]

In the cave were also found, according to Sir Henry, tusks of Mammoth ; but, according to Buckland, elephant. The distinction may be important.

If the skeleton and the elephant, together with hyæna and bear, were contemporary, England would be continental, and Paviland perhaps a hundred miles from the sea. In this case shells of *Littorina littoralis* would be somewhat out of place.

Moreover, we are told that the bones contained a small quantity of a yellow substance like adipocere, which is practically altered marrow. I should be inclined to submit that bones containing marrow associated with *Littorina littoralis* are as unlikely to be Palæolithic as any ancient bones could be.

With regard to the Liége caves, Schmerling (we are told) says that the human bones "agree in colour, in the degree of decomposition, and in the way they occur, with those of the extinct beasts. . . . ." Buckland, however, says, "The human bones found in these caves

[1] Rel. Dil., p. 165. [2] Evans' "Ancient Stone Implements," 2nd ed., p. 487.

are in a state of less decay than those of the extinct species of beasts."[1] This evidence is absolutely irreconcilable.

It is no object of mine to prove Buckland right or wrong, but I would ask any unprejudiced reader whether on the above evidence, and especially taking into account the momentous fact of 2½ feet of stalagmite covering a skull in a cave of the present coastline—whether it would be worthy of a cautious scientist to accept such evidence as that of the caves of Burrington, Wookey Hole, Paviland, or Liége, as proof of the contemporaneity of man with the extinct animals. As any stick is good enough to beat a dog, so any myth seems sufficient to depreciate Buckland.

In the September number of the GEOLOGICAL MAGAZINE, Professor Rupert Jones writes: "The Rev. McEnery's reports on Kents Cavern were finished about 1826 . . . whilst McEnery's paper was supposed to be 'lost,' but really kept in the background by influence of the Rev. Dean Buckland. . . ." The fact is the Rev. J. McEnery never wrote a paper, nor reports. What he did write, viz. rough notes, were not finished in 1826; nor did Dean Buckland influence McEnery's decisions except by legitimate argument, which happened in McEnery's case to convince. McEnery's manuscripts were so truly lost that they were sold at auction with old sermons, and only recovered years later in a fragmentary condition. Parts are therefore still lost, a lamentable fact, beyond supposition.

The following are McEnery's own words:—

"On the 14th August, 1829, visited the cave accompanied by Master Aliffe." (Trans. Dev. Assoc., vol. iii, p. 295.)

"Vid. Buckland's resumé in reference to the discovery of human bones in Diluvium in Bridgewater Treatise. I cannot sum up better than with his remarks." (Trans. Dev. Assoc., vol. iii, p. 225.)

Then as to the cause of delay in publication of his works:—

"Had I not devoted so long a period to personal examination of all the circumstances attending this delicate question, in common with others I should have fallen into the error of supposing human remains to be contemporaneous because conjoined with the deposit of mud and bones. Into this opinion I fell at first from the discovery of flint blades in contact with both in several parts of the cavern and the alternation of the stalagmite, and I communicated my impressions to Dr. Buckland with all the earnestness of sincere conviction. It was to this doubt chiefly is owing the original delay in the publication of my labours. It is only from extended observation over the entire field of the cavern that I have come to the conclusion that human bones are long posterior to the sediment containing pebbles and bones, and that they date no more than half-way down from that period.

"If ever a temptation offered for passing the human skeleton for a *Homo diluvii testis* it is here, when accompanied by his weapons he is found mixed up in the Diluvium with the bones of elephant, etc.; but a regard to truth compels us to declare that all the attendant circumstances concur to the conclusion that his bones were deposited here by human hands to a period long posterior to the introduction of even the muddy sediment found in the cavern." (Trans. Dev. Assoc., vol. iii, p. 226.)

[1] Bridgewater Treatise, Buckland, vol. i, p. 598.

The importance of the differences of opinion between Buckland and McEnery have been greatly exaggerated. McEnery writes :—

"It is painful to dissent from so high an authority, and more particularly so from my concurrence generally in his views of the phenomena of these caves, which three years personal observation has in most every instance enabled me to verify." (Trans. Dev. Assoc., vol. iii, p. 338.)

The sole point here in dispute was the mode of accretion of stalagmite ; a question of the most profound indifference, as both Buckland and McEnery were agreed that the bones of men were absent from the 'Diluvium,' that the flint implements were introduced after the extinct mammalia, and that the flints were post the Noachian deluge. Where flints occurred under stalagmite Buckland contended that the stalagmite had been broken through and perhaps reformed. McEnery denied this, and maintained that the stalagmite was continuous and intact. But, as McEnery did not limit the rate of accretion, and believed the stalagmite was all posterior to the Noachian deluge, the difference of opinion is of no possible importance. Buckland and McEnery were equally mistaken ; and McEnery's error was perhaps more dangerous than Buckland's. The soundness of stalagmite is a question of inspection, whereas the rate of growth varies immensely. Were McEnery right as to the post-Diluvian age of the Kent's Cavern stalagmite, the cave would be no witness for the antiquity of man.

In 1840 Mr. Godwin-Austen wrote :—"Human remains and works of art . . . . occur throughout the entire thickness of the clay." (See Trans. Dev. Assoc., vol. ii, p. 498.)

In 1841 Dean Buckland maintained that "in Kent's Cavern . . . . the Celtic knives were found in holes dug by art, and which had disturbed the floor of the cave and the bones below it." (Quoted Rep. B.A., 1877, p. 55.)

In 1847 the Report of a Committee of the Torquay Natural History Society was submitted by Mr. E. Vivian to the Geological Society and to the British Association. Of the former Mr. Vivian writes in 1859 : The paper "was considered so heterodox that its insertion in the Transactions was delayed until the late lamented Dr. Buckland could again visit the cavern, which he was never able to accomplish" ("Cavern Researches," p. 60, note). The Council and Officers of the Geological Society included De la Beche, Lyell, Owen, Sedgwick, Forbes, Falconer, Murchison, and Darwin. But not Buckland.

In Section C of the British Association at Oxford it was reported that the undisturbed stalagmite three feet thick had been broken through in three places, and flint knives found in each instance. The President of Section C was Buckland.

Thus, at last, the great fact of Kent's Cavern was publicly advertised, under the auspices of Buckland, who did not, as did the Geological Society, postpone the publication for further enquiry.

Long after Buckland's death, the British Association spent sixteen years and nearly £2,000 in breaking up the stalagmite of Kent's Cavern, and removing the subjacent four feet of deposits. Hundreds

of tons were taken out of the cavern, and with what result? So far as human bones were concerned, Buckland and McEnery were justified to the letter. Not a single human bone was proved from the cave earth (McEnery's 'Diluvium'). The human bones in the black mould of the cave were introduced by man, were not Palæolithic, and the cautious reasoning of the great explorers had saved them from what might have well been to them an everlasting blunder.

As to the flints, the two clerics were both mistaken. The flints were indeed coeval with the extinct mammalia, and they certainly were older than the reputed date of the Noachian deluge. What, then, can we fling in the face of these immortals? Just that they carried caution to excess—a vice which is better than most virtues.

Buckland and McEnery at any rate took a sane view of stalagmite and stone implements. They did not contend that the Kent's Cavern stalagmite entered in the form of a magma, or that the flints were not artificial, or that in a tunnel cave bones fell through the roof, or that Kent's Cavern was a mine in which that grand beast the hippopotamus (which never was in the cave) worked as a beast of burden. Yet all these things were gravely or even indignantly suggested to crush the unorthodoxy, scientific or theological, of the harassed explorers. But it has remained for the second year of the twentieth century to see an article in the GEOLOGICAL MAGAZINE on the Progress of the Modern Theory of the Antiquity of Man with no reference in it to the most important literature of the subject, the literature of Kent's Cavern.

IV.—NOTES ON THE ARENIG ROCKS NEAR ABERDARON, CARNARVONSHIRE.

By CHARLES A. MATLEY, B.Sc., F.G.S.

INTRODUCTION.

THE geology of the Lleyn peninsula has from time to time attracted the attention of geologists, and several workers have added much to our knowledge of this district; but their researches have been mainly confined to (1) the strip of ancient rocks (usually assigned to the pre-Cambrian) in the west between Porth Dinlleyn and Bardsey Island, and (2) the igneous rocks lying in the Ordovician ground which occupies the eastern and larger portion of the peninsula. Thus the Ordovician sedimentary rocks have largely escaped attention, a result probably also due to their monotony, to the rarity of fossiliferous localities, and to the great extent to which the beds are concealed beneath accumulations of drift.

It has long been known that in certain localities these sedimentary rocks are of Bala age, and that in other localities they belong to the Arenig series, but the general structure of the region remains obscure, for no serious attempt appears to have been made to work out the detailed stratigraphy of the area or to trace the various horizons zone by zone.

From the results obtained during a short visit to Aberdaron last summer the present writer is encouraged to think that such an

attempt would meet with some measure of success. Fossils, though far from common, are not so rare, even in the Arenig beds, as has been generally supposed, and sufficient have now been found in the small area at present touched upon to show that it contains beds of Lower, Middle, and Upper Arenig age. The writer hopes to return to the district and continue the examination of the area, but meanwhile the following preliminary account summarizing the results so far attained may be of interest.

Area examined.

The Ordovician ground examined is a tract about four miles wide around the shores of Aberdaron and Llanfaelrhys Bays. A projecting outcrop of pre-Cambrian rock divides this area into two parts, a western portion abutting on Aberdaron Bay and an eastern portion adjoining Llanfaelrhys Bay.

Western or Aberdaron Tract.

The Ordovician beds here, except where bounded by the sea, are limited in all directions by faults which throw them against the pre-Cambrian rocks of the district. The general structure appears to be a syncline. Much of the ground is covered by thick masses of glacial drift.

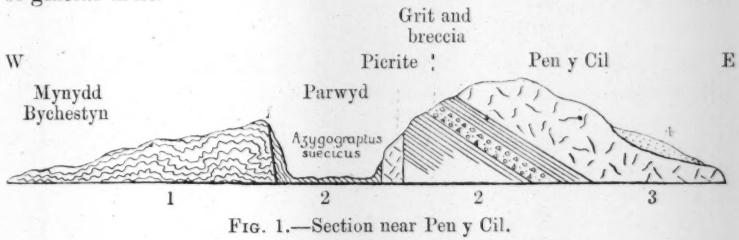


Fig. 1.—Section near Pen y Cil.

4. Drift.
3. Dolerite Sill.
2. Arenig rocks.
1. Pre-Cambrian.
f. Fault.

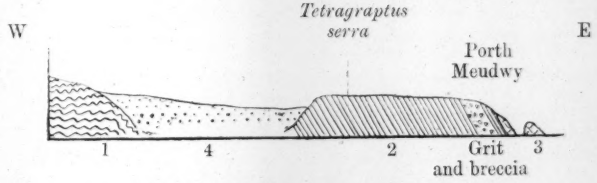


Fig. 2.—Section at Porth Meudwy.

On the western side of Aberdaron Bay we have the following sequence in descending order, as shown in Figs. 1 and 2 :—

(3) Dark shales surmounted by a thick sill of dolerite (Pen y Cil dolerite).
(2) Grit and breccia, forming a zone about 60 or 70 feet thick. The breccia contains abundant fragments derived from the pre-Cambrian region to the west.
(1) Dark slaty shales, usually hard and sandy, with numerous courses of fine sandstone.

The base of the succession is not seen. A specimen of *Tetragraptus serra*, Brongn. (= *T. bryonoides*, Hall), was found some 300 feet or so below the summit of (1).

Further north, in a small black-shale quarry near Aberdaron, a number of graptolites were obtained, probably *Didymograptus extensus*, Hall, and *D. nitidus*, Hall. Loose blocks found in the neighbourhood also yielded graptolites of the *D. extensus* type, though the actual species to which these forms belong have not been made out with certainty. They are very probably of Lower Arenig age.

Where the western boundary fault reaches the sea at Parwyd a mass of black shale with numerous flaggy bands of sandstone is wedged in between the pre-Cambrian rocks and a dyke-like mass of picrite which separates it from zone (1) of the above table. These Parwyd beds yielded *Azygograptus suecicus*, Moberg, and *Didymograptus*, sp., perhaps *hirundo*, and they represent a higher horizon than the beds with the 'extensiform' graptolites at Aberdaron.

The beds of the Aberdaron tract appear, therefore, to comprise rocks ranging from the Lower to the Middle and perhaps Upper Arenig. All the graptolites discovered are forms found in the "Middle Skiddaw Slates"[1] of the English Lake District.

Eastern or Llanfaelrhys Tract.

The rocks dip easterly, and consist of sandy and argillaceous shales, often containing flaggy and thick bands of sandstone. At various horizons in the series are injections of basic igneous rock, usually dolerite sills. Figs. 3 and 4 are sections across part of this area.

The succession is best observed along the coast, and may be stated in descending order as under :—

[Laccolite of Mynydd Penarfynydd, a mass of hornblende-picrite and hornblende-dolerite.]

(6) Penarfynydd shales with *Didymograptus bifidus*, Hall.

[Dolerite sill near Porth Llawenan.]

(5) About 6 feet of dark shale containing layers crowded with *Didymograptus bifidus*, Hall.

[One or more dolerite sills; coast obscured by drift.]

(4) Ironstone and manganese zone of Nant y Gadwen, comprising also concretionary blue mudstone and dark shales.

(3) Dark shales of Nant y Gadwen, characterized by *D. hirundo*, Salter. In these beds is a band that has been worked for manganese.

[Maen Gwenonwy dolerite sill.]

(2) Flaggy sandstones and sandy shales.

[Gallt y Mor dolerite sill.]

(1) A thick series of dark slaty beds, often sandy, and containing, especially in their lower part, courses of sandstone.

The base of (1) is not seen, being faulted against a strip of pre-Cambrian rocks.

Geologists are indebted to the late Mr. Tawney[2] for the first

[1] As defined by Miss Elles, Quart. Journ. Geol. Soc., vol. liv (1898), pp. 528 and 530.

[2] Geol. Mag., 1880, p. 211. Fossils, including graptolites, were also found in the neighbourhood of Llanfaelrhys by the Geological Survey; see Ramsay, Geol. North Wales, 2nd ed. (1881), pp. 215 and 377.

discovery of fossils in zone (6). The writer has not yet found 'tuning-fork' graptolites below zone (5). Both these upper zones are clearly of Upper Arenig or Llanvirn age. The ironstone and manganese band (4) is of stratigraphical interest, because it is found again about a mile away at Tyddyn-Meirion and at Benallt-bach, Rhiw. At the latter place these beds are worked commercially for manganese, and the blue concretionary mudstones there have provided specimens of *Azygograptus suecicus*, Moberg, and other fossils. The ironstone occurs in massive beds, and is of an altogether different character from the pisolitic iron-ore, supposed to be of Arenig age, found at Llanengan a few miles further east.

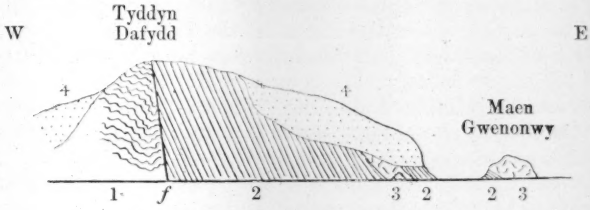


FIG. 3.—Section near Maen Gwenonwy.

4. Drift.
3. Dolerite Sill.
2. Arenig rocks.
1. Pre-Cambrian.
f. Fault.

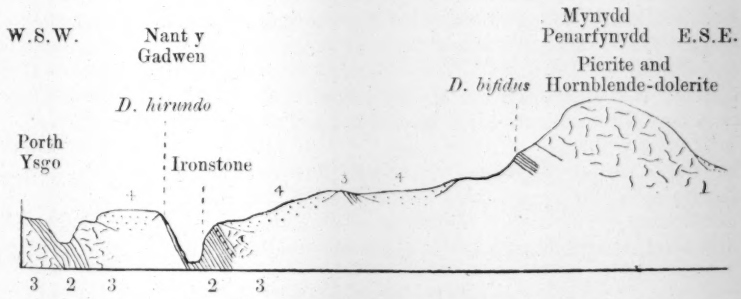


FIG. 4.—Section from Porth Ysgo to Mynydd Penarfynydd.

The lowest beds of this tract have not yet yielded fossils. They are possibly of Lower Arenig age, and they pass upwards, through Middle Arenig, into Upper Arenig beds. All the graptolites here recorded are forms which also occur in the Middle Skiddaw Slates.

CONCLUDING REMARKS.

The writer is indebted to Miss E. M. R. Wood for very kindly examining and identifying the graptolites and for information concerning their zonal value. Other fossils such as *Ogygia*, *Trinucleus*, *Lingula*, and *Orthoceras* have been obtained in several localities, but their species have not yet been worked out. The graptolites, however, show sufficiently well that the greater part of the Arenig is represented in the area described. The lowest beds of the series are

cut out by faults; the beds leading up to the Llandeilo may be looked for in the country east of Rhiw.

Two points of interest remain to be briefly considered. The highly contorted, crushed, and complicated region to the west of Aberdaron has been spoken of in this paper as "pre-Cambrian," but the writer, in thus expressing the general opinion of geologists, does not thereby intend to exclude the possibility of some of the beds being of later age. The great difference of tectonic arrangement on opposite sides of the boundary fault is very striking. In comparison with the intense complication and the metamorphism of the "pre-Cambrian" region the Arenig rocks may be said to be practically undisturbed, and a strong impression of a great difference of age between the two sets of rocks is thus left upon the observer's mind. Direct evidence that this inference is well founded is now afforded by the rock-fragments occurring in the Arenig breccia of the western side of Aberdaron Bay. These fragments consist of pieces of schist, quartz-granulite, etc., unmistakably derived from rocks identical with many of those lying on the other side of the boundary fault, and their condition of alteration corresponds with the present stage of metamorphism of the latter. It is therefore clear that the metamorphism of this "pre-Cambrian" area had been practically completed not later than early Arenig times.

In this pre-Cambrian region patches of jasper are found associated with green basic igneous rocks. A similar association of rocks has been recently described as occurring along the eastern border of the Highlands of Scotland, where they have been designated the "Jasper and Green-Rock Series." On the grounds of their resemblance to the Arenig radiolarian cherts and lavas of the Southern Uplands of Scotland this Jasper and Green-Rock Series has been considered to be "most probably of Arenig age." [1] Whatever may be the merits of the case as regards the Highland Border rocks, it seems inadmissible to apply the same argument of analogy to the jasper-containing group of the Lleyn, in view of the quite distinct character and altogether different mode of occurrence of the undoubted Arenig rocks near by.

V.—Woodwardian Museum Notes: Salter's Undescribed Species. VI.[2]

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE VI.)

PTEROPODA.

Conularia clavus, Salter. (Pl. VI, Figs. 1, 1*a*–*c*.)

1873. *Conularia clavus*, Salter, n.sp.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 153 (*a* 878).

1891. *Conularia clavus*, Woods: Cat. Type Foss. Woodw. Mus., p. 119.

The original specimen (*a* 878) is in a very perfect condition and comes from the Wenlock Limestone of Dudley. It also belongs to

[1] G. Barrow: Quart. Journ. Geol. Soc., vol. lvii (1901), p. 342.

[2] For previous articles see Geol. Mag., 1901, pp. 5, 106, 246, 355, and 576.

the Fletcher Collection. There is no other specimen of this species in the Woodwardian Museum. Salter calls it "a new square species."

Diagnosis.—Shell forming a regular four-sided elongated pyramid. Sides equal, flat, except near aperture, where the middle of each face is slightly impressed, causing transverse section of aperture to be slightly quadrilobate. Transverse section below aperture square. Angles of pyramid marked by narrow groove. Aperture with margins inflected; lips of anterior and posterior faces large, semicircular, meeting in middle line; lips of lateral faces smaller, not so much infolded, not meeting in middle. Apex wanting, being broken off at transverse diaphragm. Faces of pyramid ornamented by 50–60 fine raised transverse ribs, angulated upwards along median line at obtuse angle of about 140° and set with small sharp equidistant tubercles, giving a moniliform appearance. The interspaces between the ribs are broad, flat, and smooth. The ribs of the adjacent faces are seen to alternate at the angles. There are 5 or 6 of these ribs on the anterior and posterior lips of the mouth, but only 1 or 2 on the lateral lips. There is no median longitudinal line down the centre of each face of the shell, nor any longitudinal ornamentation.

Measurements.

Apical angle	20°
Rate of tapering	1 in 3
Width at mouth	5 mm.
Length (minus apex)	13·5 mm.

Remarks.—This species belongs to Holm's[1] group *Moniliferæ* of the genus *Conularia*, and shows many points of resemblance to the species *C. monile* (Lindström),[2] but in the British form the tubercles on the transverse ribs are smaller, situated further apart, and not laterally compressed, and the ribs on which they are set are not placed so close together.

Conularia bifasciata, Salter. (Pl. VI, Figs. 2, 2*a*.)

1873. *Conularia bifasciata*, Salter MSS.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 171 (*a* 926).
1891. *Conularia bifasciata*, Woods: Cat. Type Foss. Woodw. Mus., p. 119.

There is only the original specimen (*a* 926) of this species in the Woodwardian Museum. It comes from the Lower Ludlow beds of Leintwardine, and on the same slab are numerous specimens of *Monograptus leintwardinensis*. Salter says of this specimen, "only shows one face, and that of a young specimen." The thin shell is covered with irregular wrinkles owing to unequal compression.

Diagnosis.—Shell large, pyramidal, apical angle 25°, of extremely thin substance. Surface marked by one small, straight, narrow median ridge, running longitudinally down the centre of the face. On each side of this ridge is a nearly parallel, narrow, dark line representing an internal septum. These two septa are straight and nearly parallel to each other, only slightly diverging in their course

[1] Holm, Sver. Kamb. Silur. Hyolith. o. Conular: Sver. Geol. Undersokn., ser. c, No. 112 (1893), p. 154.
[2] Lindström: Sil. Gastrop. Pterop. Gotl. (1884), p. 44, pl. i, figs. 9–12.

from the apex towards the apertural margin. Surface of shell ornamented by very fine, closely placed transverse lines, gently arched forwards parallel to the margin of the aperture, and closely set with microscopically minute oval tubercles, longitudinally elongated and arranged in regular longitudinal lines, giving a shagreen-like appearance to the shell. This ornamentation is not interrupted in the least in crossing the median ridge or the edges of the septa.

Measurements.

Length	65 mm.
Width of aperture	22 mm.
Apical angle	20°

Remarks.—The two Swedish Silurian species which very closely resemble *C. bifasciata* are *C. bilineata* (Lindström) and *C. aspersa* (Lindström).[1] Both of these possess the thin shell, the curious pair of septa in the middle of the face, and the same style of ornamentation. *C. bilineata* also shows traces of the small median ridge between the septa. The ornamentation of *C. aspersa* appears to resemble that of *C. bifasciata* most closely. But both the Swedish species differ in their apical angle, being much larger, i.e. from 30° to 35° instead of 20°. It is noteworthy that the specimen of *C. bilineata* described by Lindström (loc. cit.) is apparently preserved in much the same way as our specimen of *C. bifasciata*, for both have their extremely thin shell wrinkled and of a chestnut-brown colour.

Hyolithes Homfrayi, Salter. (Pl. VI, Fig. 3.)

1873. *Theca Homfrayi*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 8 (*b* 263).
1891. *Hyolithes Homfrayi*, Woods: Cat. Type Foss. Woodw. Mus., p. 120.

This species is described by Salter (op. cit.) as "much longer than *Theca corrugata*." There are several specimens of this form in the Woodwardian Museum, one of the three original slabs labelled *b* 263 showing several individuals. Unluckily none are well preserved, and consequently the description of the species cannot be quite satisfactory. They come from the Menevian beds of Tyddyngwladis, and were presented by Mr. D. Homfray.

Diagnosis. — Shell conical, elongated; apical angle 10°–15°. Face (ventral?) shows one longitudinal, narrow median ridge apparently accompanied by a slight infolding of the shell, with a lateral ridge on each side of it close to the margin of the face, apparently representing the inflexed margins of the dorsal face. In one specimen strongly marked growth-lines, arched forwards, cross the face between the lateral ridges, but outside these ridges their direction slightly changes. Aperture prominent, arched forwards. A distorted oval object near the mouth of the figured specimen may represent the operculum.

[1] Lindström: Sil. Gastrop. Pterop. Gotl. (1884), pp. 45–47, pl. i, figs. 4–8; pl. vii, figs. 1–3; pl. xix, fig. 1. Holm: Sver. Kamb. Sil. Hyol. o. Conul. (1893), p. 134, t. vi, figs. 38–42, 43–46.

Measurements.	mm.	mm.
Length	25	37+
Width at aperture	5	?

Remarks.—*Hyolithes Homfrayi* is closely allied to *H. bijugosus* (Salter)[1] from the Tremadoc beds. The apical angle, longitudinal keels, and prominent mouth are similar; but the stronger transverse striæ and the approximation of the lateral keels to the margin in *H. Homfrayi* are points of difference. It may be compared with the Swedish species *H. pennatulus* and *H. triumvir*,[2] but the material is so poor that this species of Salter's cannot be held to rest on a very firm basis.

Hyolithes sulcatus, Salter. (Pl. VI, Fig. 4.)

1873. *Theca sulcata*, Salter, n.sp.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 17 (*b* 322).

1891. *Hyolithes sulcatus*, Woods: Cat. Type Foss. Woodw. Mus., p. 121.

The two original specimens, *b* 322, which come from the base of the Upper Tremadoc of Llanerch, west of Portmadoc, and were presented by Mr. D. Homfray, consist of an internal cast and the impression of the same. Since the aperture is more or less broken and imperfect it is not possible to decide if it is the dorsal face of the shell, but I am inclined to think it is for reasons which are given below. Salter describes this species as "broad and short with longitudinal folds."

Diagnosis.—Shell conical, broad, short; apical angle nearly 30°, trilobed, being divided into three elevated longitudinal ridges of approximately equal size by two sharply impressed angular grooves. The median ridge is rounded and convex; the lateral ones are angulated sharply down their centre. There are indications of several (four or five) small, rounded, longitudinal ribs running down the median ridge, and one or two less distinct ones on each of the lateral ridges. No transverse striation is present.

Measurements.	mm.
Length	23
Breadth at front end	10

Remarks.—In *Hyolithes bijugosus* (Salter) the convex side (which is called by Salter in this species the dorsal) is described as ridged with three distinct keels, the central one of which is the strongest, but the small apical angle (10°–12°) and the transverse lines of growth and absence of longitudinal ribs distinguish this species.

Hyolithes Billingsi,[3] from the Cambrian of Pioche, Nevada, resembles *H. sulcatus* more closely in having an apical angle of nearly the same size and the flattened dorsal side ornamented with three longitudinal ridges divided by furrows. The longitudinal ribs figured by Holm[4] in many Swedish species are found on the convex ventral side, but in those forms (*H. pennatulus*, *H. triumvir*, etc.) in which the edges of the dorsal face are folded round to the ventral

[1] Mem. Geol. Surv., vol. iii, 2nd ed. (1881), p. 559, pl. x, figs. 19, 20.
[2] Holm: Sver. Kamb. Sil. Hyol. o. Conul. (1893), t. iii, figs. 1–5, 6–11, etc.
[3] Walcott: "Fauna of the *Olenellus* Zone" (1890), p. 620, pl. lxxv, figs. 1, 1*a–c*.
[4] Holm: Sver. Kamb. Silur. Hyol. o. Conul. (1893), t. iii, figs. 1–5, 6–11, etc.

side the trilobation of the ventral face is very marked. The transverse striation is, however, a feature in these forms. The material at our disposal is not sufficiently well preserved to decide if *H. sulcatus* belongs to this latter group, called by Holm (op. cit., p. 154) *Magnidorsati*, subgroup *Carinati*, and it is even impossible to say positively if our specimens exhibit the dorsal or ventral face of the shell, though I am inclined from the resemblance to *H. bijugosus* and *H. Billingsi* to consider it to be the dorsal.

HYOLITHES TRILINEATUS, Salter. (Pl. VI, Fig. 5.)

1873. *Theca trilineata*, Salter MSS.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 18 (*b* 333).

1891. *Hyolithes trilineatus*, Woods: Cat. Type Foss. Woodw. Mus., p. 121.

Salter describes this form as "a small species with longitudinal lines." The original specimen comes from the base of the Upper Tremadoc, Moel-y-Gest, and was presented by Mr. D. Homfray. It is not in a very good state of preservation, and shows only the inner side of the dorsal face, but there are several other specimens from the Tremadoc beds of Tyn-y-llan, Portmadoc, which show the characters more distinctly.

DIAGNOSIS.—Shell conical. Apical angle 15°. Dorsal face provided with strong median longitudinal carina for two-thirds of its length from pointed apex. Anterior third of dorsal face flattened with prominent semicircular lip; carina obsolete on this portion of shell. Carina bordered by a sharp deep groove on each side which likewise die out in front. Between these grooves and the lateral edges of the dorsal face are faint indications of longitudinal ribs. On the anterior, flattened third of the shell two weak indistinct ribs may be distinguished, apparently not continued posteriorly towards the apex.

Faint transverse striæ, arched forwards, are present. (These are best shown on some of the Tyn-y-llan specimens in which the shell is preserved, but are visible also in the type-specimen.)

MEASUREMENTS.	mm.
Length	16
Width at mouth	6

REMARKS.—This species resembles *H. aratus* (Salter)[1] from the Lower (and Upper?) Tremadoc in the raised keel along the dorsal surface, the transverse arched striæ, and size of the apical angle, but differs in the reduction of the length of the keel and flattening of anterior portion.

EXPLANATION OF PLATE VI.

FIG. 1. *Conularia clavus*. × 2½.
,, 1*a*. Ditto, showing groove at angle. × 2½.
,, 1*b*. Ditto, mouth. × 2½.
,, 1*c*. Ditto, ornamentation. × 10.
,, 2. *Conularia bifasciata*. Nat. size.
,, 2*a*. Ditto. × 30.
,, 3. *Hyolithes Homfrayi*. × 2.
,, 4. *H. sulcatus*. × 2.
,, 5. *H. trilineatus*. × 2.

[1] Mem. Geol. Surv., vol. iii, 2nd ed. (1881), p. 559, pl. x, figs. 15, 21.

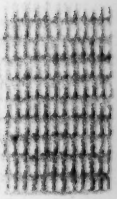
1

1 b

1 a

1 c

2



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G.M.Woodward del. et lith.

West, Newman imp.

Palæozoic Pteropoda.

VI.—Note on the genus *Tmaegoceras*, Hyatt.

By G. C. Crick, F.G.S., of the British Museum (Natural History).

In a recent number of the "Neues Jahrbuch" (1901, Bd. ii, Heft 3, pp. 158–170, 6 text illust.) Dr. J. F. Pompeckj, of Munich, has an interesting paper on the genus *Tmaegoceras*. The genus was established by Hyatt[1] in 1889 for the two very rare Ammonites from the Lower Lias of the Alps, *Ammonites latesulcatus*, F. v. Hauer,[2] and *Arietites levis*, G. Geyer.[3] To these, in 1899, G. Bonarelli[4] added a third species, *Tmaegoceras Paronai*, from the Lower Lias of the Central Apennines, at the same time assigning to this genus Schafhäutl's *Ammonites Helli*.[5] But as Mojsisovics[6] pointed out in 1893, Schafhäutl's species is a *Tropites*, whilst *Ammonites latesculcatus*, F. v. Hauer, *Arietites levis*, G. Geyer, and *Tmaegoceras Paronai*, G. Bonarelli, have nothing whatever to do with that genus. Of these three species Dr. Pompeckj regards *Ammonites latesulcatus*, F. v. Hauer, and *Tmaegoceras Paronai*, G. Bonarelli, as generically identical, and with them he unites also Quenstedt's *Ammonites dorsosulcatus*[7] and his own new species (*T. crassiceps*[8]), which he describes from the Lower Lias (zone of *Arietites Bucklandi*) in the neighbourhood of Tübingen (Württemberg). He considers *Arietites levis*, G. Geyer, to be a true Arietite, probably related to *Arietites ophioides* (d'Orb.), Wähner,[9] or *Arietites Cordieri*, Canavari.[10]

As emended by Pompeckj the genus includes the four following species:—

1. *Tmaegoceras latesulcatum*, F. v. Hauer, sp. Lower Lias: Adneth, Bischofsteinbruch (Nordostalpen).
2. *Tmaegoceras dorsosulcatum*, F. A. Quenstedt, sp. Upper boundary of the Zone of *Schlotheimia angulata*: Vaihingen, near Stuttgart (Württemberg).

[1] A. Hyatt, "Genesis of the Arietidæ": Mem. Mus. Comp. Zool. Harvard Coll., xvi, No. 3 (1889), p. 125.

[2] F. v. Hauer, "Über die Cephalopoden aus dem Lias der nordöstlichen Alpen": Denkschr. Akad. Wissensch., Wien, Bd. xi (1856), p. 44, pl. ix, figs. 1–3.

[3] G. Geyer, "Über die liasischen Cephalopoden des Hierlatz bei Hallstatt": Abhandl. d. k.k. geol. Reichsanst., Wien, Bd. xii, No. 4 (1886), p. 252, pl. iii, figs. 10*a–e*.

[4] G. Bonarelli, "Cefalopodi Sinemuriani dell' Appennino Centrale": Palæontogr. ital., vol. v (1899), pp. 66–7, fig. 1.

[5] Schafhäutl, "Geognostische Untersuchungen des südbayerischen Alpengebirges," 1851, p. 107, pl. xv, fig. 21.

[6] E. v. Mojsisovics, "Die Cephalopoden der Hallstätter Kalke": Abhandl. d. k.k. geol. Reichsanst., Bd. vi, No. 2 (1893), pp. 201, 202, 207.

[7] F. A. Quenstedt: "Die Ammoniten des Schwäbischen Jura," p. 109, pl. xiii, figs. 33–35 (1885).

[8] J. F. Pompeckj, "Ueber *Tmaegoceras*, Hyatt": Neues Jahrb., 1901, ii, pp. 162–165, text-figs. 1*a–i*.

[9] Fr. Wähner: "Beiträge zur Kenntniss der tieferen Zonen des unteren Lias der nordöstlichen Alpen" (Beitr. zur Pal. Österr.-Ung., etc., Bd. vi, 1888), p. 164, pl. xxv, fig. 5.

[10] Fr. Wähner: op. cit., vi (Beitr. zur Pal. Österr.-Ung., etc., Bd. viii, Heft 4, 1891), p. 193, pl. xvii, figs. 1–4; pl. xviii, figs. 1–6.

3. *Tmaegoceras crassiceps*, n.sp. Zone of *Arietites Bucklandi*: neighbourhood of Tübingen (Württemberg).
4. *Tmaegoceras Paronai*, G. Bonarelli. Zone of *Arietites obtusus* (?): Ponte Grosso, near Ponte Alto (Central Apennines).

We note that in his paper Dr. Pompeckj makes no reference to Michelin's *Ammonites Lacordarii* [*airei*][1] from the Lower Lias of France, and the object of the present note is to call attention to that species, because it seems to be related to Hyatt's genus.

Michelin's description of the species is as follows:—

"A. testâ discoideâ; infractibus 4–5, subinvolutis lævibus; lateribus convexis; canaliculatis propè penultimum anfractum; dorso carinato; carinâ parvâ, ad utramque partem altè canaliculatâ; aperturâ oblongâ, in medio depressâ.

"Latit. testæ [= diameter] 90 millim.; latit. inf. ult. [= height of outer whorl] 30 millim.; latit. anf. penult. [= height of penultimate whorl] 20 millim.; latit. apert. [= width of aperture] 42 millim.; long. apertur. [= height of aperture] 30 millim.

"Cette espèce d'Ammonite, qui est fort rare, et dont je dois la connaissance à mon ami M. Lacordaire, ingénieur en chef du canal de Bourgogne, a été trouvée par lui dans des couches subordonnés du Lias, aux environs de Pouilly en Auxois, département de la Côte-d'Or. Elle est à l'état de moule intérieur, et ne paraît pas avoir eu une plus grande dimension, attendu qu'on ne voit la trace d'aucune cloison sur les trois quarts du dernier tour.

"La carène, se trouvant plus basse que les deux côtés extérieurs des canaux qui l'accompagnent, donne au dos de cette coquille l'aspect d'une corniche.

"Ma collection et celle de M. de Roissy."

The description is accompanied by three figures representing the lateral, apertural, and peripheral aspects of the type-specimen. The suture-line is not figured separately, but it is depicted in the lateral and apertural views of the fossil.

We have not seen an example of this rare species, nor do we know where Michelin's type is, but there is in the British Museum Collection [register number 37,150] a plaster cast of the type-specimen, and it seems to us most probable that the species belongs to Hyatt's genus *Tmaegoceras*. To the dimensions given above it may be added that the width of the umbilicus is 40 mm. Michelin's figures give a very good idea of the general form of the specimen, but the suture-line, though probably well shown on the fossil, does not appear to be at all accurately drawn. The suture-line has not been reproduced on the cast. The general form of the species appears to come very near Pompeckj's new species *T. crassiceps* and Bonarelli's *T. Paronai*, and the suture-line, according to Michelin's figure, certainly suggests the characters of that of Von Hauer's *Ammonites latesulcatus*, the type of *Tmaegoceras*, rather than that of an *Arietites*.

[1] H. Michelin: Mag. de Zool., v (1835), Classe 5, pl. 67.

VII.—Some Railway Cuttings in Suffolk.

By Horace B. Woodward, F.R.S.

1. *Yarmouth and Lowestoft Direct Railway.*

YARMOUTH and Lowestoft have long been connected by railways, but although the Great Eastern Company had provided a choice of routes, there was no direct way. This is now in process of construction by a joint arrangement between the Great Eastern, Great Northern, and Midland Railway Companies; and the route, for the most part within a mile of the sea-coast, is from the Great Eastern Station at Lowestoft through Gunton, Hopton, Corton, and Gorleston to the Yarmouth Beach Station, a distance of a little more than nine miles.

Where the new railway leaves that of the Great Eastern Company, about half a mile west of the Lowestoft Station, there is a cutting in buff, false-bedded, slightly gravelly sand belonging to the Middle Glacial Drift. Further on, Boulder-clay was cut into, to the east of Normanston Court, and it has there been burnt for ballast. A few glaciated Belemnites were noticed, but derived fossils were not so plentiful as in some other localities.

South of St. Margaret's Church and east of Normans Hurst the junction of the Boulder-clay with underlying Middle Glacial sand was well shown in the railway cutting on the north side of the road. The Boulder-clay contained much chalk and many flints and galls of sand, and it rested on buff sands. At the junction a good deal of sand was incorporated with the Boulder-clay, and the sand was streaked with chalky detritus. The sand below was exceedingly fine.

East of St. Margaret's Church, sand and pebbly gravel (Plateau Drift) were exposed, while to the north of the main road to Corton, beyond Belle Vue Park, a wide excavation for the railway-station showed the following sequence:—

		ft.	in.
Soil with much blown sand	1 ft. to	1	6
Plateau Gravel — Yellow sand		0	9
Plateau Gravel — Pebbly gravel		4	6
Middle Glacial — Fine false-bedded sand and gravel ...		1	6
Middle Glacial — Sand with streaks of loam		4	6

The pebbly gravel consisted chiefly of flint and quartz, with a few large blocks of flint and yellow micaceous sandstone. In one part it rested irregularly on the beds below, cutting into them, while elsewhere there appeared absolute conformity. Such a section suggests that when one gravel is deposited on top of another, and perhaps largely constructed from it, it may be so welded on to it that all evidence of break is obliterated.[1]

Further on to the north of Corton Long Lane, a cutting showed sandy and gravelly soil on stiff loam and Chalky Boulder-clay, the loam being in part decalcified Boulder-clay, but not wholly so. In the Boulder-clay at Corton, there were irregular masses of yellowish

[1] See also Geol. Mag., 1902, p. 30.

and reddish brown sand, coarser than the sand which locally underlies it, and containing angular flints and many flint pebbles. This did not lie in eroded hollows, but was evidently incorporated in the Boulder-clay. The sand was slightly indurated, and, in dry weather, it had separated from the Boulder-clay, and broken away in smooth dogger-like masses, which, however, merged upwards into the loam or decalcified Boulder-clay. (Fig. 1.)

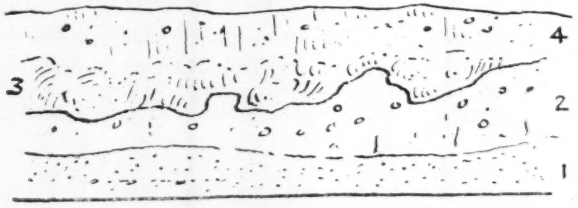

Fig. 1.—Section west of Corton.
4. Boulder-clay. 3. Indurated sand. 2. Boulder-clay. 1. Middle Glacial Sand.

Near St. Bartholomew's Church, at the junction of the Boulder-clay with the underlying buff sand, a thin pan of ironstone occurred, and here and there fine chalky detritus was present in the sand. Buff sand was also incorporated at the base of the Boulder-clay, while the portions beneath, to a depth of two feet, showed distinct evidence of disturbance. (See Fig. 2.) The Boulder-clay here contained septaria, ironstone nodules, and Jurassic fossils, also fragments of Red Chalk.

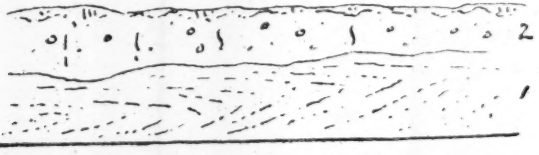

Fig. 2.—Section near St. Bartholomew's Church, Corton.
2. Boulder-clay. 1. Middle Glacial Sand.

South of Hopton there was a cutting in Boulder-clay with here and there at the base coarse sand, which was slightly indurated at the junction and merged downwards into fine current-bedded buff sand. This coarse sand was stained red and precisely like the masses elsewhere incorporated in the Boulder-clay. Here, again, the sands below the Boulder-clay were distinctly contorted, and in places where the junction was less even. At one spot the sand contained scattered pieces of a broken ochreous band. (Fig. 3.) Elsewhere, between Boulder-clay and sand there was a layer of unctuous clay and loam streaked with chalky detritus.

North of Hopton the cutting showed 10 feet of sand and gravel, and beyond Kennel House brown and white sand belonging to the Middle Glacial Drift, overlaid by 5 to 8 feet of angular and pebbly Plateau gravel. This gravel was bleached and contained many unworn flints, as well as pebbles of flint, quartz, etc.

In the long cutting at Gorleston fine sections were to be seen of false-bedded gravelly sand with worn fragments of *Cyprina*, *Cardium*, and other derived shells, and on top of this drift there was a patch of Boulder-clay to the south-west of St. Andrew's Church.

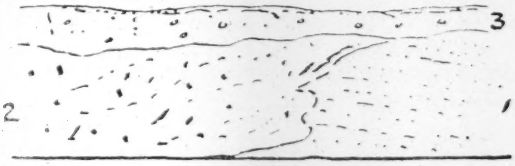

FIG. 3.—SECTION SOUTH OF HOPTON.

3. Boulder-clay. 2. Middle Glacial Sand with broken ochreous band. 1. Middle Glacial Sand.

Beyond Gorleston the railway traverses the marshland below Breydon Water, and terminates on the Blown Sand and Shingle to the north of Yarmouth.

2. *Cutting at Halesworth.*

The widening of the Great Eastern Railway just north of Halesworth Station opened up during June of last year (1901), a fine section of the Chalky Boulder-clay with an included mass of chalky and flinty gravel and seams of clay. At the northern end of the cutting, which was made on the eastern side of the railway, the Boulder-clay contained nests of brown and fine white sand, also a mass of shattered chalk; and it presented its usual characters of stiff blue clay with many glaciated pieces of chalk

N. S.

FIG. 4.—SECTION AT HALESWORTH STATION.

Chalky Boulder-clay with included gravelly bed.

and septaria, unrolled flints, fragments of Red Chalk, Kimeridge Shale, and numerous Jurassic Ammonites and Belemnites.[1] Of most interest was the gravelly mass (Fig. 4), which was made up as follows:—

	feet.
Brown loamy and chalky gravel	4 or 5
Slightly indurated clayey and marly band with flints, and fragments of shale	1½
White and buff sand with chalk grains, and seams of chalky and flinty gravel	5 or 6
Brown stony clay	2
Very fine sand	1
Chalky and flinty gravel	7 or 8
Brown marly clay	½

The gravelly beds contained numerous pebbles of chalk, many black flint pebbles, and pebbles of quartz and quartzite, as well as

[1] A collection of the fossils has been made by Mr. Charles Ganz, of Aldborough.

angular flints and broken flints. Such a deposit was evidently formed by a stream due to melting of the débris-laden ice, and its chalky constituents have been preserved owing to the protection afforded by the Boulder-clay, for as a rule the Glacial gravels are decalcified.

It is from beds of this nature in the Boulder-clay that supplies of water are sometimes met with by well-sinkers.

The cutting extended about 15 chains, and in its highest part was about 25 feet above the rails.

NOTICES OF MEMOIRS

I.—The Gold Fields of Wainad, in Southern India. By H. H. Hayden, B.A., F.G.S., and F. H. Hatch, Ph.D., F.G.S. Memoirs of the Geological Survey of India. 8vo; vol. xxxiii, pp. 48, with seven plates. (Calcutta, 1901.)

THE Geological Survey of India have issued a memoir dealing with the goldfields of Wainad in the Malabar District. Mining operations having been recently abandoned as unproductive, and reports by previous experts on their value being conflicting, a more exhaustive mineral survey than any hitherto undertaken was made by Mr. H. H. Hayden and Dr. F. H. Hatch, the services of the latter as a mining specialist being temporarily secured by the Indian Government. Typical reefs having been selected, their systematic examination was proceeded with, and numerous specimens obtained at fixed intervals were analyzed at Calcutta. The results of the analyses, averaging about 2 dwt. of gold to the ton, are disappointing, and corroborate the opinion formed on the ground that the grade of ore is too low to justify the further exploitation of the district. The region furnishes a striking example of the unreliability of old native workings as a safe criterion of the existence of payable metal. With the employment of forced labour along surface outcrops and the use of primitive machinery the cost of production is necessarily reduced to a minimum, and the popular idea that the crude methods of the ancients necessitated the presence of high-grade ore is a fallacy that should be taken to heart by investors in other parts of the world at present under exploitation. J. B. H.

II.—Perim Island and its Relations to the Area of the Red Sea. By Catherine A. Raisin, D.Sc.[1]

THIS paper describes briefly rock specimens from Perim Island collected and placed at the disposal of the authoress by Captain J. A. Rupert Jones, now stationed at Aden.

The island, as shown in the Admiralty chart, has somewhat of a horseshoe shape, enclosing a harbour opening to the south. Low plains, less than 12 feet above sea-level, extend in from the coast, especially at the north, and consist of raised beaches, but most of the southern and eastern parts are hilly, reaching 249 feet at the highest point.

[1] Read before the British Association, Section C (Geology), Glasgow, Sept., 1901.

The specimens sent are all from volcanic rocks. The surface, according to Captain Rupert Jones, is composed mostly, to a depth of about 7 feet, of loose blocks (4 feet or less in diameter), often imbedded in calcareous sand or mud. The underlying rock is exposed in cliffs and in quarries, and occurs generally in roughly horizontal layers. One mass *in sitû* (near Balfe Point) is a not very basic basalt (almost an andesite) crowded with felspar microliths with marked fluidal orientation, and is probably a lava-flow. Another reddish rock with scattered rounded vesicles (from a cliff north-east of the harbour) approaches a microcrystalline basalt in character, and consists of much plagioclase, clear gum-like augite, some red-brown ferruginous olivine or pyroxene, and a little black speckled glassy base. In another spot (near Balfe Point) a whitish tuff or fine agglomerate is quarried, and consists largely of fragments of pumice with some broken felspar, augite, and other crystals.

The surface blocks in one or two examples consist of fragmental rocks. One is a red, more basic tuff, containing thin black streaks, apparently of a spherulitic glass. The blocks, however, are mostly scoriaceous and vesicular, petrologically generally basaltic, and similar to the underlying rocks described above, but with some variation, as if they might represent a broken lava crust. They are crossed by veins of calcite, and the ashy materials and other fragments are often cemented by calcareous deposits.

The history of Perim Island belongs mainly to the Tertiary era. We may infer that the Red Sea, from its general contours and the steep descent of the bed towards a central depression, forms part of the Great Rift Valley, extending from Lake Tanganyika to the Jordan, along which at so many places volcanic outbursts on a large scale have occurred. Both in Arabia and in Abyssinia extensive tracts of volcanic rocks are found of more than one period. The rocks of Perim belong probably to the later or so-called Aden group. The raised beaches of the island are an evidence of oscillations of level, which are proved by upraised and submerged coral reefs to have affected other parts of the Red Sea. Denudation and weathering of the surface took place, and calcareous sediment was deposited, while at different times coral reefs became established in the adjacent shallow seas.

REVIEWS.

I.—Catalogue of the Fossil Fishes in the British Museum (Natural History). By Arthur Smith Woodward, LL.D., F.R.S., F.G.S. Part IV: pp. xxxix, 636, with 19 Plates and 22 Figures. 8vo. (London, 1901.)

DR. A. SMITH WOODWARD and the British Museum are to be congratulated on the completion of this important memoir on Fossil Fishes, the fourth volume of which has been for long anxiously expected by all Ichthyologists. For those specially at work among the fossil forms, it will be a welcome and an indispensable

aid. We have no other modern book dealing in detail with the whole group of Fossil Fishes, from all parts of the world; and as a work of reference these four volumes may be regarded as a companion of the "Recherches sur les Poissons Fossiles," by Louis Agassiz, which was completed in 1843. The simple and unostentatious title of "Catalogue" under which Dr. Smith Woodward's work is published is misleading. It is true that it includes a catalogue of the British Museum Fossil Fishes, but it is much more than appears from the title: it is a critical revision of this interesting but difficult assemblage of fossils, bringing together the work of the last fifty years, which has been scattered through various publications in all parts of the world. Moreover, to each species, genus, and larger group characteristic descriptions are given, as well as their synonyms, and this renders the so-called "Catalogue" a memoir of the Fossil Fishes which will be of permanent value, and cannot fail to be the work of reference for a long time to come. The British Museum possesses an unrivalled series of fossil fishes, accumulated during many years, and including several well-known and valuable collections. Free access to such an extensive collection was a necessity before a task, like that undertaken by Dr. Smith Woodward, could be entered upon with any hope of success; but in the work now before us the author has shown how fully he has been able to take advantage of these materials, by producing a memoir which is an honour to himself and to the institution under whose auspices it is published.

It is now twelve years since the first volume was issued, the second volume appearing in 1891, and the third volume in 1895; each of these being noticed in this Magazine.[1] Now, after an interval of six years, we welcome the fourth volume, which completes the work.

The first volume is entirely devoted to the fossil Elasmobranchii, the Sharks and Rays as we ordinarily understand them, and is thus complete in itself; but the fishes with shagreen-like scales and spines to their fins, known as the Acanthodii, seem to bridge over the gap between ordinary Sharks and certain forms that were formerly classed as ganoids. Although the Acanthodii are included by Dr. Smith Woodward in the Elasmobranchii, yet he has found it convenient to place them at the beginning of his second volume, which also contains the Holocephali (Chimæroids), the Ostracodermi (*Cephalaspis* and *Pteraspis*), the Dipnoi (*Coccosteus, Dipterus, Ceratodus*, etc.), and a part of the Teleostomi. The last-named subclass embraces all the ganoids not included in the above-mentioned groups, as well as the true bony fishes or Teleosteans. The Teleostomi are divided by Dr. Smith Woodward into the Crossopterygii, or those fishes with lobed or fringed fins, and the Actinopterygii, those with ordinary non-lobed fins. The Crossopterygii are treated of in the second volume, as well as the Palæozoic Actinopterygii belonging to the Chondrostei, namely, *Palæoniscus, Platysomus*, and their allies. The third volume is practically an

[1] See GEOL. MAG., 1889, p. 366; 1891, p. 132; and 1896, p. 124.

account of the Jurassic ganoids, or those Actinopterygian Teleostomi that were dominant during the deposition of the first half of the Secondary rocks, and includes such genera as *Chondrosteus*, *Semionotus*, *Lepidotus*, *Dapedius*, *Eugnathus*, *Pachycormus*, and *Pholidophorus*. Many forms of Pycnodonts are described both from Jurassic and Cretaceous rocks, while *Lophiostomus* and *Protosphyræna* are representative genera of Cretaceous age. *Amia* and *Lepidosteus* are Tertiary types of these fishes which have continued to exist to the present day.

The fishes which remain for consideration are just those which have for so long been known as Teleosteans, or true bony fishes, and the fourth volume of the work, now published, is really an account of the Bony Fishes of the Cretaceous and Tertiary formations.

The present volume begins with Isospondylous Actinopterygii; that is, those fishes with non-lobate fins, which have vertebræ more or less ossified, without indications of pleurocentra or hypocentra, and having none of them fused together; the lower jaw also is formed of only two or perhaps three distinct bones. The three families of these fishes which have the closest affinities with the old-time ganoids, were included with those forms in the previous volume.

Among the remaining families of the Isospondyli are to be found many remarkable genera of Cretaceous bony fishes; and these, with the other suborders, may now be considered more in detail. The Isospondyli include among them the Elopidæ and Chirocentridæ, which are "the most important Cretaceous families of primitive bony fishes"; they were at that period particularly abundant and widely distributed, and a few of their descendants are living at the present day. The Elopidæ are of especial interest, inasmuch as they retain the *gular plate*, so characteristic in Jurassic fishes, and here appearing for the last time; indeed, in some of the genera it is quite rudimentary. *Isteus* is a noteworthy genus, on account of its close relationship with the living deep-sea *Bathythrissa*.

In the Cretaceous period were many and striking forms allied to the living but primitive *Chirocentrus*; among these may be mentioned the giant *Portheus* of North America, which is represented also in this country by more than one species. The well-known *Saurodon* and *Saurocephalus* are likewise members of this family, and Dr. Smith Woodward regards the *Thrissops* of the Upper Jurassic as a near ally.

Some years ago, it will be remembered, the reptilian jaw which Owen called *Mosasaurus gracilis*, now in the Brighton Museum, was relegated to the piscine genus *Pachyrhizodus*, of the family Elopidæ; it is pleasing, therefore, to know that a renewed examination of the type shows the correctness of Owen's determination, and that this specimen is to return to its place among the Mosasaurian reptiles.

True Clupeoids are well represented in the Cretaceous rocks, "and their skeleton is so closely similar to that of the typical Jurassic Leptolepidæ that they may well be direct descendants of the latter. . . . . Most of the Cretaceous forms are typical Clupeidæ, and

they have scarcely changed during subsequent epochs. A few, however, discovered only in the Cretaceous rocks, are of especial interest as exhibiting the precocious development of a character, namely the pelvic fins near to the pectoral arch, which was never permanently acquired by fishes with so primitive a skull, but soon became the common feature of the spiny-finned or acanthopterygian families." These aberrant forms have another interest for geologists who have made the Chalk their special study. These precocious herrings, if we may so call them, are none other than the characteristic fishes of the Chalk, which we have all along known as *Beryx*, or rather it is that portion of them left to us after Dr. Smith Woodward had, about twelve years ago, removed some of the species to the genus *Hoplopteryx*. But now we learn that our supposed Cretaceous representatives of the deep-sea *Beryx* are little more than common herrings, and do not even belong to the family of the Berycidæ; they have been renamed *Ctenothrissus*, and placed in a new family, the Ctenothrissidæ. *Beryx*, it is said, is not certainly known as a fossil. The Chalk without *Beryx* is almost like "Hamlet" without the central figure. Much as we may regret this change of names, we must, even while smarting under the correction, appreciate the acumen which has detected the form of the lowly herring under the guise of the highly specialized *Beryx*, and be thankful for the elimination of a fundamental error.

Dr. Smith Woodward says that these Ctenothrissidæ are essentially Clupeoids with the pelvic fins displaced forwards and situated nearly under the pectorals. If this be so it is a remarkable fact, and not a little difficult to understand why these should have become extinct, while other fishes, which underwent a similar modification during the Cretaceous era, have retained it until the present day and have become a predominant race.

The true family of the Clupeidæ does not seem to be represented in British Cretaceous rocks, although occurring in deposits of that age in other parts of the world; it is especially abundant in the Upper Cretaceous beds of the eastern Mediterranean. In Tertiary times, however, these fishes were certainly living in the British area and had an almost worldwide distribution.

The Decertidæ, those remarkable elongated fishes with longitudinal rows of paired scutes with which we are familiar in the English Chalk, are known only from beds of that age, but had then a wide distribution. "They are interesting as being the earliest type of fish in which evidence of a distensible stomach has been observed."

The well-known *Enchodus* and its allies, which are exclusively Cretaceous fishes, are variously specialized by the development of large teeth and dermal scutes. The author thinks that this family may have furnished the ancestors not only of the Berycidæ but also of the Scopelidæ.

The family Esocidæ, with its only genus *Esox*, is also included in the suborder Isospondyli; it is sparsely represented in later Tertiary beds, and fragments of fishes, which cannot be distinguished from the common pike, *Esox lucius*, are met with in Pleistocene deposits.

The fresh-water Siluroid and Cyprinoid fishes, which are the chief forms included in the suborder Ostariophysi, are not known until the Tertiary period, but the remains met with in the Lower Eocene are highly specialized, and one Siluroid, at least, cannot be separated from the living *Arius*.

The Eels, which are comparatively primitive fishes, showing in many points degenerate specialization, are represented in the Cretaceous rocks by forms displaying most of their peculiarities, except the absence of the caudal fin. Dr. Smith Woodward thinks these fishes could not have been derived from any known form of Teleostean, but must have been directly descended from some Mesozoic ganoid form.

Nearly all the Cretaceous Acanthopterygian fishes are referable to the Berycoids and Scombroids, and it is among these that the oldest true Acanthopterygian fishes are found. The Upper Cretaceous genera are said to be but little specialized, "and it seems probable that they actually originated at about the period of deposition of the Chalk of the northern hemisphere." *Hoplopteryx*, the genus to which certain species formerly called *Beryx* are now referred, is remarkable for the excessive development of the mucous cavities about the head.

The presence of what seems to be a true Percoid fish in the uppermost Cretaceous of France leads Dr. Smith Woodward to infer that many such forms existed during that period, but they still remain undiscovered. Scombroids and Berycoids are found in Tertiary deposits, and "the principal types had already appeared early in the Eocene period; and among these fishes there are many which cannot be distinguished by their skeletons from genera which still survive." Cod-fishes and flat-fishes date back to the Oligocene and Upper Eocene, but no generalized ancestor has been recognized.

Dr. Smith Woodward tells us that "as soon as fishes with a complete osseous endoskeleton began to predominate at the dawn of the Cretaceous period, specialisations of an entirely new kind were rapidly acquired. Until this time the skull of the Actinopterygii had always been remarkably uniform in type. . . . . The pelvic fins always retained their primitive remote situation, and the fin-rays never became spines. During the Cretaceous period the majority of the bony fishes began to exhibit modifications in all these characters, and changes occurred so rapidly that, by the dawn of the Eocene period, the diversity observable in the dominant fish-fauna was much greater than it had ever been before. At this remote epoch, indeed, nearly all the great groups of bony fishes, as represented in the existing world, were already differentiated, and their subsequent modifications have been quite of a minor character."

The author had evidently hoped that the detailed study of the Cretaceous and Tertiary bony fishes would have thrown greater light on the origin of modern forms, for he says "the result, however, is much less satisfactory than might have been expected from the study of animals which lived under conditions most favourable for their preservation as fossils. The circumstance that a very large

proportion of the Tertiary fishes are known only from detached otoliths, suffices to indicate the extreme imperfection of the geological record in their case."

The comparatively meagre materials, where so much was to be expected, lead the author to say further that "Palæontology has, indeed, hitherto revealed as little concerning the origin of the dominant Tertiary fishes as of the Tertiary mammals."

This seems a somewhat extreme view after Dr. Smith Woodward has shown us so many affinities between the Cretaceous and more modern fishes, and is perhaps to be read rather in the light of his own larger expectations than as a conclusion to be drawn from the premises he has himself laid before us in these volumes. To make the cases of the Fishes and the Mammals parallel, the gap between the Tertiary and Mesozoic fishes should have been at least as great as that between Teleosteans and Sharks. But whatever may be our views as to the light thrown by Cretaceous fishes upon the origin of the more highly developed forms of the Tertiary period, there can be but one opinion as to the extreme value of the work accomplished by Dr. Smith Woodward among fossil fishes, the results of which are embodied in these four volumes.

Of the 19 plates which illustrate this volume 18 have been drawn by Miss G. M. Woodward, with the usual excellent result. There are perhaps no more difficult objects to draw than fragmentary fossil fishes, and an examination of these plates shows the extreme care which has been bestowed upon them. We are told that the instructive restorations in the text are by the same lady's hand; but there are other text figures the origin of which is not stated. The figures on plate xvii are evidently reproductions from photographs, and are admirable representations of the fossils.

In the preface, which old friends will be pleased to see signed by Dr. Henry Woodward, we are told that already there is a necessity for a supplementary volume. E. T. N.

II.—The Water Supply of Berkshire from Underground Sources. By the late J. H. Blake, F.G.S., with contributions by William Whitaker, F.R.S. Memoirs of the Geological Survey. 8vo; pp. 115. (London: printed for H.M. Stationery Office, 1902. Price 3s.)

TWO years ago attention was drawn to the publication of a memoir on the Water Supply of Sussex, and the present work may be regarded as a companion volume. There is a general account of the strata, with special reference to their water-bearing capacities; there are records of numerous borings in Berkshire, and some analyses of the waters are given. The work should prove of great service to those in search of a supply of water in the county, and even 'diviners' might find the information not without value. The records of the borings will also prove useful to those who are studying the varying characters and thicknesses of the strata, and the underground geology so far as it is known. Nowhere at present have Palæozoic rocks been reached in Berkshire.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—January 22nd, 1902.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "The Fossiliferous Silurian Beds and Associated Igneous Rocks of the Clogher Head District (County Kerry)." By Professor Sidney H. Reynolds, M.A., F.G.S., and Charles I. Gardiner, Esq., M.A., F.G.S.

After a brief account of the bibliography of the district, the authors proceed to give a detailed description of the coast from Dunquin past Clogher Head to Coosglass (south of Sybil Point), and of the western side of Smerwick Harbour. They next deal with the inland exposures, which are not very frequent, but include considerable rock-masses at Croaghmarhin and Minaunmore Rock. The rocks consist of sandstones, slates, calcareous flags, ashes and ashy conglomerates, rhyolitic lava-flows, and various intrusive rocks. The general structure is an S-shaped fold, inverted towards the north so that the dip of the beds is approximately south-easterly, and the oldest beds occur to the north, at Coosglass. Both anticline and syncline are faulted, and a patch of Old Red Sandstone is caught in under the synclinal thrust at Coosmore. Fossils, mainly corals, brachiopods, lamellibranchs, and gasteropods, are fairly abundant; but trilobites are rare and graptolites absent. The whole of the fossiliferous rocks are of Silurian age; the majority of those exposed on the coast are of Wenlock or Wenlock-Llandovery age, while the majority of those exposed inland are of Ludlow age. The general classification is as follows:—

		Feet.
Lower Devonian.....	Dingle Series.	
Ludlow	5. Croaghmarhin Beds: calcareous sandstones and flags of Ludlow age	? 1,000
Wenlock	4. Drom Point Beds .....about	600
	3. Red sandstones and ashes, with green ash at the top.....	350
	2. Clogher Head Series: calcareous flags and slates, with abundant contemporaneous igneous rocks	550
Wenlock-Llandovery	1. Ferriter's Cove Beds: chiefly calcareous flags, with a subordinate development of contemporaneous igneous rocks	2,300
?	Smerwick Beds.	

Contemporaneous volcanic rocks are first met with low down in the Wenlock-Llandovery Series, and reach their maximum in the Wenlock Series, especially in the southern part of the area. There are ashes but no lavas in the Ludlow. The volcanic rocks are all of acid character, and include nodular, banded, and non-banded rhyolites, with tuffs and ashes both coarse and fine. The Dingle Beds appear to be conformable, but movement occurred before the Old Red Sandstone Conglomerate was laid down, and the overfolding

and thrusting probably took place during the post-Carboniferous period of earth-movement. Before the last movement fine-grained diabasic rocks ('greenstones') appear to have been intruded. The thickening of the volcanic rocks to the southward seems to indicate that the vents must have been situated in this quarter. The beds as a whole were deposited in shallow water in the proximity of land, and they point to the existence of rocks, such as granites, not now known at the surface in the district.

2. "A Process for the Mineral Analysis of Rocks." By W. J. Sollas, D.Sc., LL.D., F.R.S., F.G.S., Professor of Geology in the University of Oxford.

The method proposed is to obtain a quantitative estimation of the mineral composition of a rock, and from the known composition of the minerals to calculate the percentage composition of the rock. The specific gravities of the minerals are first determined by means of a diffusion column of methylene-iodide and beads of known specific gravity, and the presence or absence of particular minerals settled for a certainty. Next, the separation of the minerals in a weighed quantity of the powdered rock is undertaken by means of a special separator; the method being illustrated by the example of a rock containing orthoclase (sp. gr. 2·56), quartz (2·65), andesine (2·67), biotite (3·1), pyroxene (3·3), and magnetite. The first separation would be with a liquid of sp. gr. 2·885, the mean of that of andesine and biotite; the next with a liquid of sp. gr. 2·66; the next 2·605, and so on for the other constituents. The separated minerals are dried and weighed, the loss distributed, and the analysis checked by comparing the specific gravity of the rock in bulk with that calculated from the specific gravity and proportion by weight of its constituents. In making choice of particular mineral analyses for calculating the chemical composition, there are three guiding principles: the analysis should be that of a mineral obtained from the same kind of rock as the one under investigation; if possible, from the same locality; and with the same specific gravity. The process was tested on specimens of kentallenite supplied by Mr. Teall and of gabbros from Skye by Mr. Harker, and in both cases the results compared closely with those obtained from bulk analysis of the same rocks. A further test was the comparison of the mineral analysis by Miss Davies of a specimen of Devonshire granite with Phillips's published analysis; also of syenite from the Plauens'chergrund, and of tonalite from Adamello, with published analyses.

II.—February 5th, 1902.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair.

Mr. H. Bauerman, in exhibiting a remarkable Crystal of Cinnabar from the Mercury-mines in the province of Kwei-chau (China), observed that it was a completely developed penetration-twin of two rhombohedra, attached to a mass of crystalline quartz. He drew attention to the simple character of the form from this locality, as compared with those of the crystals from Almaden and Avala.

The following communications were read:—

1. "The Matrix of the Suffolk Chalky Boulder-clay." By the Rev. Edwin Hill, M.A., F.G.S.

The author has been examining with the microscope washed residues from Boulder-clays. He is able to group together the specimens from localities along a belt of country from Lowestoft to Bury St. Edmunds, as containing granules of Secondary clays and limestones. Other specimens contain granules which may be the same kind decomposed, others granules of other kinds; all these lie outside the belt occupied by the group, though some are very near it. The granules of the group, derived from Secondary rocks, may all have come from the west.

Certain peculiar round grains, found generally, except in the extreme east and north, are also probably from Secondary rocks, and they too point to a western origin.

The clays of the group, though some occupy the coast-cliffs, contain so little sand, that they cannot be supposed to have been brought from the side of the sea, that is, from the east.

All the residues have been examined for coal-dust. Though this is contained in Glacial clays along the eastern coast of England as far south as the Wash, and probably farther, it is either altogether absent from the group or present only on its eastern edge. It appears to be absent from the clays which border the group on the north.

These results combined lead to the conclusion that the materials of the matrix in the Suffolk Chalky Boulder-clay were not brought from the east or north, but from inland; and not from so far inland as the Coalfields. Their sources therefore lie on a limited belt, bordering the Boulder-clay area.

With this agrees the evidence of the included boulders as a whole.

2. "On the Relation of certain Breccias to the Physical Geography of their Age." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

The author has endeavoured in this paper to collect from published accounts and his own observations the evidence which certain well-known and important beds of breccia afford as to the physical conditions prevalent when they were formed. First come sketches of the principal breccias in the Rothliegende, the brockrams of the North-West of England and similar deposits in Armagh, the breccia-beds of the Midlands and of Devon, and those of the Thüringerwald. The fragments in these vary from angular to subangular, are sometimes interstratified with beds of finer material, sometimes are themselves slightly stratified. They form marginal fringes to old land-masses, from which we may, with more or less certainty, infer them to have been derived, and are sometimes found to extend outward from them, wedge-fashion, for a few miles. They appear, for reasons given, to have been the products of bare rocky hill-slopes, rather than of mountain torrents. Floating ice has been suggested as a means of transport, though the idea that the Clent and Enville breccias indicate the former existence of glaciers is not now generally

accepted, Mr. Wickham King having shown the materials to have been derived from land-masses in the neighbourhood, and Mr. R. D. Oldham having pointed out their resemblance to certain Indian breccias.

The so-called Dolomitic Conglomerate of the South-West of England, which exhibits similar characters, though on a smaller scale, and the remarkable breccias in the Upper Oolite of Caithness described by Professor Judd, are next noticed, after which the author passes on to the breccia-beds in the Alpine Flysch, taking as examples those of the Habkerenthal and of the Val des Ormonts. The former apparently are more sporadic in character, and are suggestive of the intervention of floating ice; the latter are more regularly interbanded, and that with true marine deposits: their occurrence is extremely difficult to explain, without assuming the existence of a mountain range or a great highland district in their immediate neighbourhood.

When we seek for parallels to these breccias in deposits of late date or in process of formation, we find some resemblances to them in the breccias of Gibraltar described by Sir Andrew Ramsay and Professor James Geikie, in the stone-rivers of the Falkland Isles described by Sir Wyville Thomson, and in the breccias of Persia and other parts of Central Asia described by Dr. Blanford. The author accordingly infers the Rothliegende (and probably the Triassic) breccias to be indicative of a continental climate, due to a great extension of land or more probably the existence of a mountain region on the west—winters with severe cold and snow, but rather hot and arid summers. The Caithness breccias were perhaps more analogous to the stone-rivers of the Falkland Islands, but they also indicate a rather low temperature; while the Flysch breccias land us in the following dilemma, namely, that either similar temperatures existed in Switzerland, and that there was also an important highland district, of which no remnant can be found, within a short distance of the breccia-beds; or they must be the product of a range not inferior to the present Alps, which also has completely disappeared, and would be (for reasons given) very difficult to locate. But, even in the latter case, we seem forced to admit that a temperature, if not lower, at any rate not higher than the present, prevailed in Central Europe late in the Eocene Period.

CORRESPONDENCE.

EFFECTS OF LIGHTNING NEAR SNOWDON.

Sir,—I found last November on the hills between Cynicht and Nant y Mor two crags that had been struck by lightning. The scars on one of them were so fresh that I felt sure they had been made during a heavy thunderstorm which passed over the district on the 29th of last July, the only thunderstorm there was in this part of Wales last Summer. On asking Mr. Roberts of Gelli Iago, who farms the land, I was told that such was the case, and that the

other crag had been struck during the very heavy thunderstorm which passed over the district on a Sunday evening in the Summer of 1898 (I do not remember the exact date), when several beasts were killed by lightning. In this case some blocks have been thrown eighteen yards from the parent rock; the largest of these is between ten and eleven cubic feet in size, and there are several others lying beside it measuring three cubic feet and less. One huge block measuring sixty-four cubic feet had been thrown twenty-six yards. There are no marks of vitrifaction on the stricken crags nor on the detached fragments. The lightning has done nothing more than to break off slices and chunks and cast them to a distance.

On subsequently examining the ground again I found several other places where the rocks had been struck by lightning.

The name of the place given on the Ordnance Map is Cerig y Mellt. If this name is correct it is significant, for the words mean 'rocks of lightning'; but there is some doubt as to what is the correct name, for Mr. Roberts tells me that he learnt from his father to call the place Cerig y Myllt, which means 'rocks of the wethers.'

J. R. Dakyns.

Snowdon View, Nant Gwynant, Beddgelert.
January 25, 1902.

OBITUARY.

HON. CLARENCE KING, F.G.S.

Born . Died December 24, 1901.

In the death of Clarence King geological science has lost one who rendered distinguished service in the surveys of the United States. He was born at Newport, Rhode Island, and graduated from the Sheffield Scientific School of Yale University in 1852. He prepared the geological and topographical atlas and several important reports for the Geological Exploration of the Fortieth Parallel, and when in 1880 this and other geological surveys were amalgamated as the United States Geological Survey, Mr. King was appointed Director. Under his charge the Survey was carried on with vigour, and special investigations were made on regions of exceptional economic importance. A year later, however, Mr. King relinquished his position, desiring to devote himself unfettered to geological research. His fame, however, rests on his official work. Mr. King died at Phœnix, Arizona, on December 24th, 1901.

REV. FREDERICK SMITHE, M.A., LL.D., F.G.S.

Born 1822. Died December 9, 1900.

We learn from the recently published Address of the President of the Cotteswold Club (Mr. E. B. Wethered) of the death more than a year ago of Dr. Frederick Smithe, vicar of Churchdown in Gloucestershire. He laboured for many years with great enthusiasm